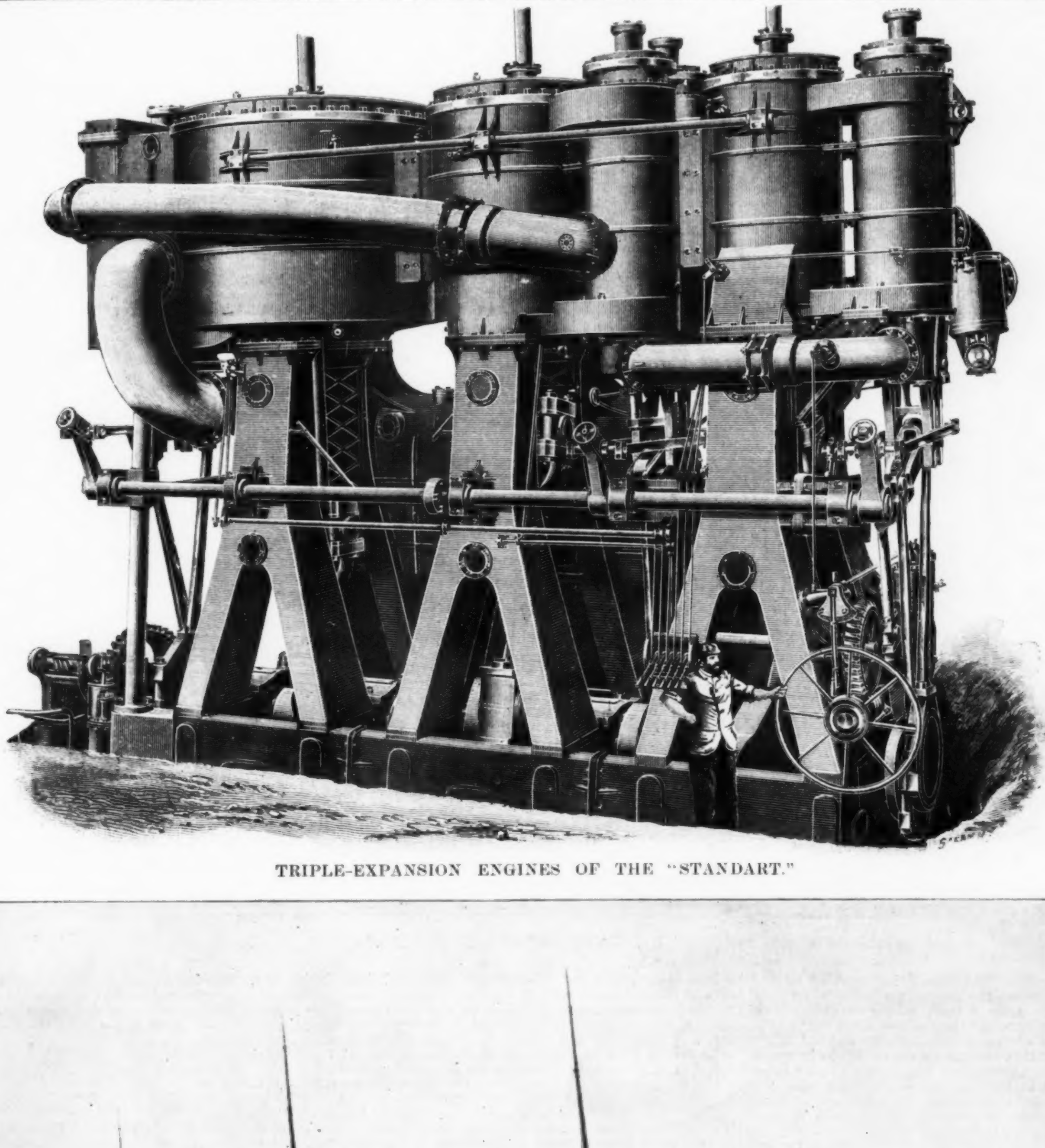
SCIENTIFIC AMERICAN SUPPLEMENT. No 1159

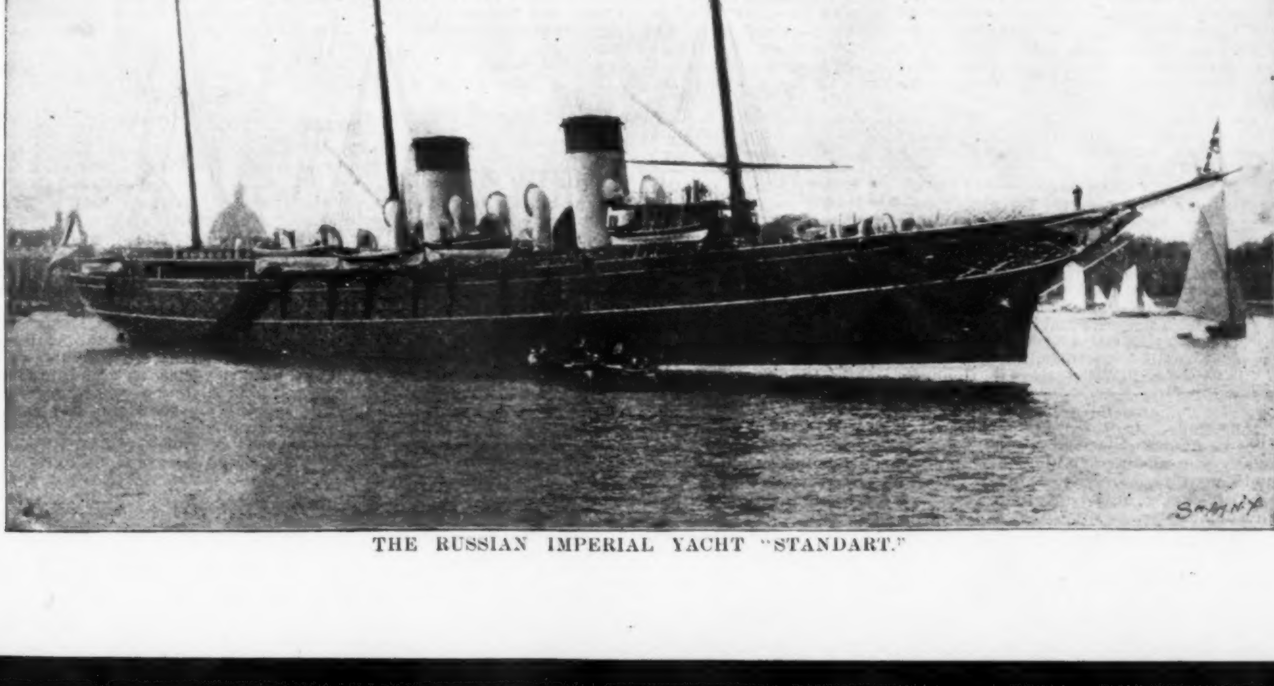
Scientific American, established 1845.
Scientific American Supplement. Vol. XLV. No. 1159.

NEW YORK, MARCH 19, 1898.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.



TRIPLE-EXPANSION ENGINES OF THE "STANDART."



THE RUSSIAN IMPERIAL YACHT "STANDART."

THE RUSSIAN IMPERIAL YACHT "STANDART."

THERE are no more splendid specimens of marine architecture afloat than the magnificent royal yachts that are being built, or have been built, for the reigning heads of Europe. The "Hohenzollern," the cruiser yacht of the German Emperor, is doubtless already familiar to our readers, and in the present issue we present illustrations of the "Standart," the sumptuous imperial yacht which has recently been completed for the Czar of Russia.

The "Standart" was commenced in 1893, when the first rivet was driven by the late Czar Alexander III., the launch taking place on March 10, 1895. The vessel was designed and built under the inspection of the chief constructor and the chief engineer of the Russian imperial navy. The leading dimensions are as follows: Water line length, 370 feet; beam, 50 feet 7 inches; draught, 20 feet; displacement, 5,255 tons. As will be seen by our front page engraving, she is rigged as a fore-and-aft three-masted schooner. She has three decks, two funnels and a clipper stem. The vessel is built of mild steel; she has cellular bottom and water ballast compartments, containing 460 tons of water.

The imperial apartments are situated on the main deck, abaft the engine space, where are placed the rooms for the emperor and empress, as well as for the dowager empress. For each of these three are arranged a sitting room, a bedroom and a bathroom. Here are also the imperial drawing and dining rooms. Further aft are rooms for four grand dukes and grand duchesses. On the lower deck aft are rooms for the imperial children and the suite. The hold between the shaft passages is arranged to store provisions and wine, and it is kept cool by means of a refrigerating plant, the walls being isolated by charcoal.

On the upper deck, aft, is a large deck house, the top of which forms a fine promenade deck. The ship is lighted by electricity, about 1,070 lamps being fixed in the various rooms and corridors. The top and side lights are also electric, the lamps being doubled in such a way that if one breaks, another will begin to glow, and at the same time a lamp in the chart room will show automatically which lamp is broken. The total length of electric wiring on board is 18 miles.

For joiner work in the cabins only the costly woods have been used. Cherry has been used in the imperial rooms, birch in the empress dowager's rooms and in the grand dukes' apartments. In the drawing room, walnut; in the imperial dining room, ash; in the corridors, oak, birds' eye maple and white beech. In the imperial rooms the walls are covered with pressed leather, cretonne and silk. No gilding whatever is used, on account of an expressed wish of the late emperor. The windows on the main deck are constructed with two round lights, which, together with the plates in which they are set, swing open horizontally. The inner window is formed of two thick plate glass panes, in gun metal frames, hinged like French windows, the whole being nickel plated.

The boilers are of the Belleville 1894 model and have 1,116 square feet of grate area and 35,250 square feet of heating surface. Each boiler contains ten elements, with ten rows of tubes in each. The boiler pressure is 245 pounds per square inch and the pressure at the engines 165 pounds; the lowering being effected by means of two reducing valves for the main engines and four for the auxiliaries. The feed pumps make use of the full boiler pressure.

The main engines, which are herewith illustrated, are twin and of the triple expansion type. The cylinders are 41⅛, 65⅛ and 105⅛ inches in diameter by 54 inches stroke. The high pressure and intermediate are fitted with piston valves (the latter having two valves), and the low pressure cylinder is fitted with a double ported trick slide valve, with relief rings on the back. The slides are worked by eccentrics in the ordinary way, the two intermediate slides having a common crosshead. The cylinders are jacketed on the top and bottom, the steam pressure in the jacket being 165 pounds for the high pressure cylinder, 75 pounds for the intermediate, and 15 pounds for the low pressure cylinder. The drainage from the steam jackets is collected by an automatic steam trap.

The crankshaft is of steel and is built up of three interchangeable pieces of steel. The shafting, 17⅛ and 18 inches in diameter, is all hollow, the central hole being 8 inches in diameter. The main condensers are of cast iron and are cast in one piece with the back standards of the low pressure and intermediate cylinders. Two centrifugal pumps, capable of delivering 2,000 tons of water per hour, feed the necessary supply of cooling water to the condensers. The suctions are arranged so that they can draw from the engine and boiler rooms, should they become flooded. An auxiliary condenser, made entirely of brass, is used for condensing the steam used by the auxiliary engines throughout the ship. The main condensers have a cooling area of 9,000 square feet; the auxiliary condenser has 1,500 square feet. The three bladed propellers are 16 feet in diameter with 27 feet pitch. The blades and bosses are of Delta metal and the studs are of phosphor bronze. Two bilge pumps draw from all the water tanks, the holds and the sea. They deliver the water to the bathrooms, the deck, the tanks and the feed pumps, and they can also pump direct to the fire hydrants. The steam cylinders are 6 inches diameter by 6 inches stroke, and the pump cylinder is 4 inches diameter. Two 7 inch bilge centrifugal pumps, intended for use in case of serious damage to the vessel, are placed below the engine room floor. The shafts, which are about 20 feet long, reach to the upper engine gallery where the pumping engines are placed, so that the water must rise to a considerable height in the engine room before the pumps are disabled. There are two pumps provided specially for fire purposes which have a capacity of 60 tons per hour.

In addition to 150 tons of water carried in the double bottom the "Standart" has a distilling apparatus whose capacity is 60 tons of fresh water in 23 hours.

Messrs. Brown Brothers' well known steering gear is used; it consists of a telemotor combined with a compound engine with cylinders 9 and 15⅛ inches in diameter by 12 inch stroke for working the hydraulic pumps. The accumulator pressure is about 50 atmospheres.

The contract for the "Standart" stipulated that she should be capable of maintaining an average speed of 20 knots for 12 consecutive hours on a mean draught of 20 feet. Her average speed on a 12 hours' trial run was 21·5 knots an hour, and during this time her performance over a measured distance of 27·5 knots showed a speed of 21·75 knots. Although the dynamos and other auxiliary machinery were running at the time of the trial, the main engines indicated 12,000 horse power.

The "Standart" has been so constructed that she can be used as a cruiser in the event of war, though there is nothing in her outward appearance to indicate the fact. It will be seen from the illustration on our front page that she is an exceedingly handsome vessel. Her clipper bow, her three pole masts and the fine sheer forward contribute to give her a rakish appearance, which is rather deceiving as to her size. The great size of the funnels also tends to dwarf the vessel, and she scarcely looks to be the 400 feet in length that she really is.

We are indebted to The Engineer, of London, for our illustrations and particulars.

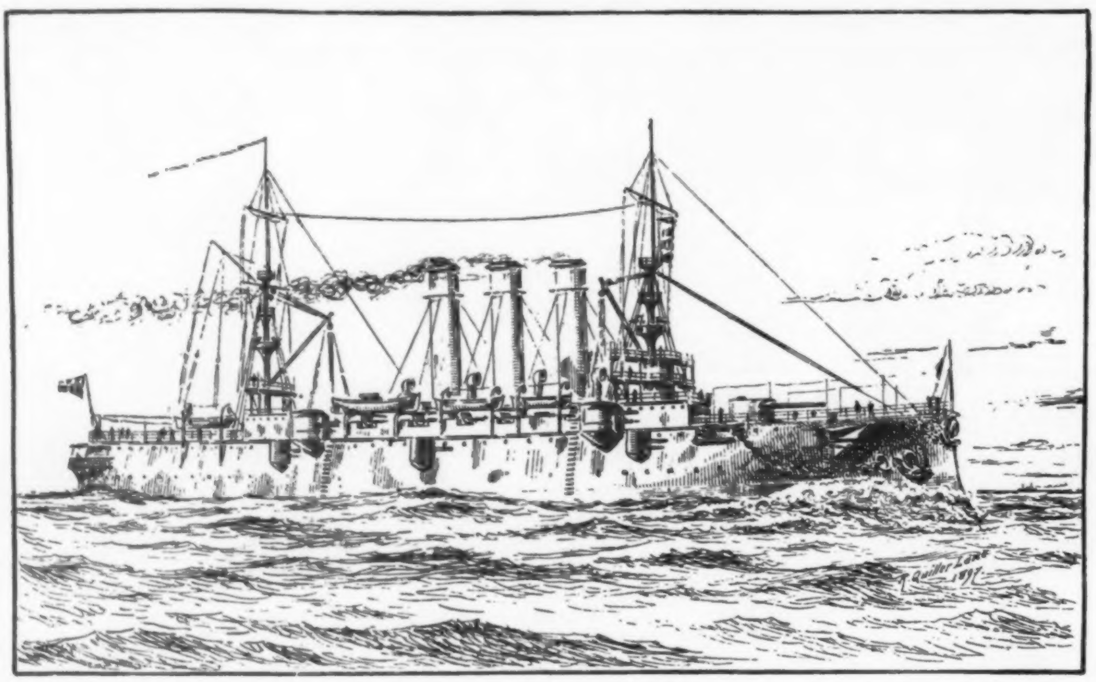
SEA POWER IN OUR CIVIL WAR.

HOW vitally land operations may be affected by the command of the sea is further illustrated by the Militar Wochenblatt in a masterly analysis of the American civil war, says The Army and Navy Journal. Powerful as were the Confederated States on land, they had from the outset to face the disadvantage that their adversaries were incomparably stronger on the sea. The Mississippi and its affluents enabled small warships and gunboats to penetrate deeply into the interior of the more southerly of the seceding States, while on the east, Virginia and North Carolina were deeply indented by the tidal mouths of the Potomac, Rappahannock, York and James Rivers, by which a means of transport was afforded all the more valuable that land communications at the time of the war were of the most primitive character. After heavy rain the roads through the vast swamps and forests of Virginia were almost impassable, and the few lines of railway were quite inadequate for any enterprises on a large scale. Sea power cut off the seceding States from all communication with the outer world, and—a cruel disadvantage for the thinly populated South—prevented her from filling up her ranks with European volunteers. It forbade the importation of warlike material, so necessary in a country but little developed industrially. In the long run these disadvantages entailed the defeat of the South, outweighing the inflexible resolution of Jefferson Davis and the really masterly conduct of the war by Lee and Stonewall Jackson. In the operation against McClellan on the Yorktown Peninsula we see the direct influence of sea power in saving a defeated army from annihilation. The pursuit of McClellan's beaten army was checked at Malvern by the Northern gunboats, which had ascended the James River, and under the protection of their guns the army was gradually embarked and transported to Washington.

After the capture of New Orleans, the Northern gunboats commanded both the upper and lower reaches of the Mississippi. Could they but effect a junction, communication between the seceding States of the East and West would be broken, and a complete stop put to the dispatch of reinforcements and supplies to the Confederate armies in Virginia from the as yet fresh and unexhausted territories west of the Mississippi. Well aware of the danger, the Confederates had strongly fortified Vicksburg and Port Hudson, in order that at these points at least they might control the passage of the river. Grant dispatched the necessary siege trains by sea from New York and Boston to the mouth of the Mississippi, the capture of both places made the Federals masters of the waterway, and the vigilant patrolling of Farragut's well organized "mosquito fleet" soon forced the enemy to abandon all attempts to dispatch supplies to Virginia from Arkansas, Louisiana and Texas.

BATTLESHIP "O'HIGGINS."

CABLE reports from London, dated March 5, state that it is rumored that the two cruisers which the Armstrongs have been building for Brazil have been sold to Spain. The inquiries also show that an agent of the Chilean government has been negotiating with a representative of the Spanish government for the sale of the battleship "O'Higgins," built by the Armstrongs for Chile. It is now believed that the deal is practically completed, whereby the splendid warship passes into the possession of Spain. The "O'Higgins" is a vessel of 8,500 tons and the horse power is 16,500. She is 411¾ feet long and 62⅛ feet beam. Her armor plate belt is 7 inches in thickness and her deck plating is 3 inches thick. The armament of the "O'Higgins" consists of four 8-inch quick firing guns, ten 6-inch guns, four 7-inch guns and ten 12-pounders, ten 6-pounders and four small rapid firing guns. She has three torpedo tubes and is estimated to steam at twenty-one and a quarter knots an hour. For our engraving we are indebted to The Shipping World.



THE BATTLESHIP "O'HIGGINS."

AN AUTOMATIC TRAIN CHECKER.

SOME little time ago, says United States Consul Morris, at Ghent, the French state railway gave a public trial to a new invention designed to effect automatically the stoppage of trains, with a view to prevent collisions, grade crossing accidents, etc. The experiments took place under the direction of the inventor, near Chartres, before many railway engineers and a numerous gathering of scientists. Those present were convinced—so state the published reports—that the apparatus fully satisfied all claimed for it.

The point chosen for the official experiments offered the greatest possible danger and difficulties. It was on the single track line between Chartres and Orleans, at the point of divergence of the branch running to Auneau and immediately over a grade crossing. There, at a distance of 250 yards from the station, the mechanism was placed in position. The invention consists of an immense hook or catch made of bent iron, to which, while rigid, a certain elasticity is given; it is fastened to the rails and regulated by a wire and lever from the station. When lying flat, trains pass it readily, but when raised it catches a lever hanging from

the passing locomotive; the latter lever then automatically causes an air valve on the engine to open, and the brakes are immediately in action. During the trial given, the train came to a standstill before reaching the station.

Careful calculation has been made that the hook or catch on the roadbed should have at the same time sufficient suppleness to insure its action.

Another ingenious arrangement connects the grade crossing gate with the invented apparatus in such a manner that the former cannot be open without the latter being in position, so that an approaching train must necessarily stop before reaching the crossing, thus avoiding all risk of injuring persons passing at the time. Further appliances are said to render the invention equally useful in preventing collisions.

A REMARKABLE OLD CRANE ON THE RHINE.

WE are indebted to the Zeitschrift für Bauwesen for the description and illustration of the old crane at Andernach on the Rhine, and well known to summer tourists. This well preserved crane was, according to documentary evidence, erected in the years 1555 to 1557 by the municipal government of Andernach, with special permission of Archbishop Adolf, of Cologne, and all receipts incident to the use of the crane from the day it was finished up to the year 1743 are recorded in the books kept by the crane masters, and still in possession of the city of Andernach.

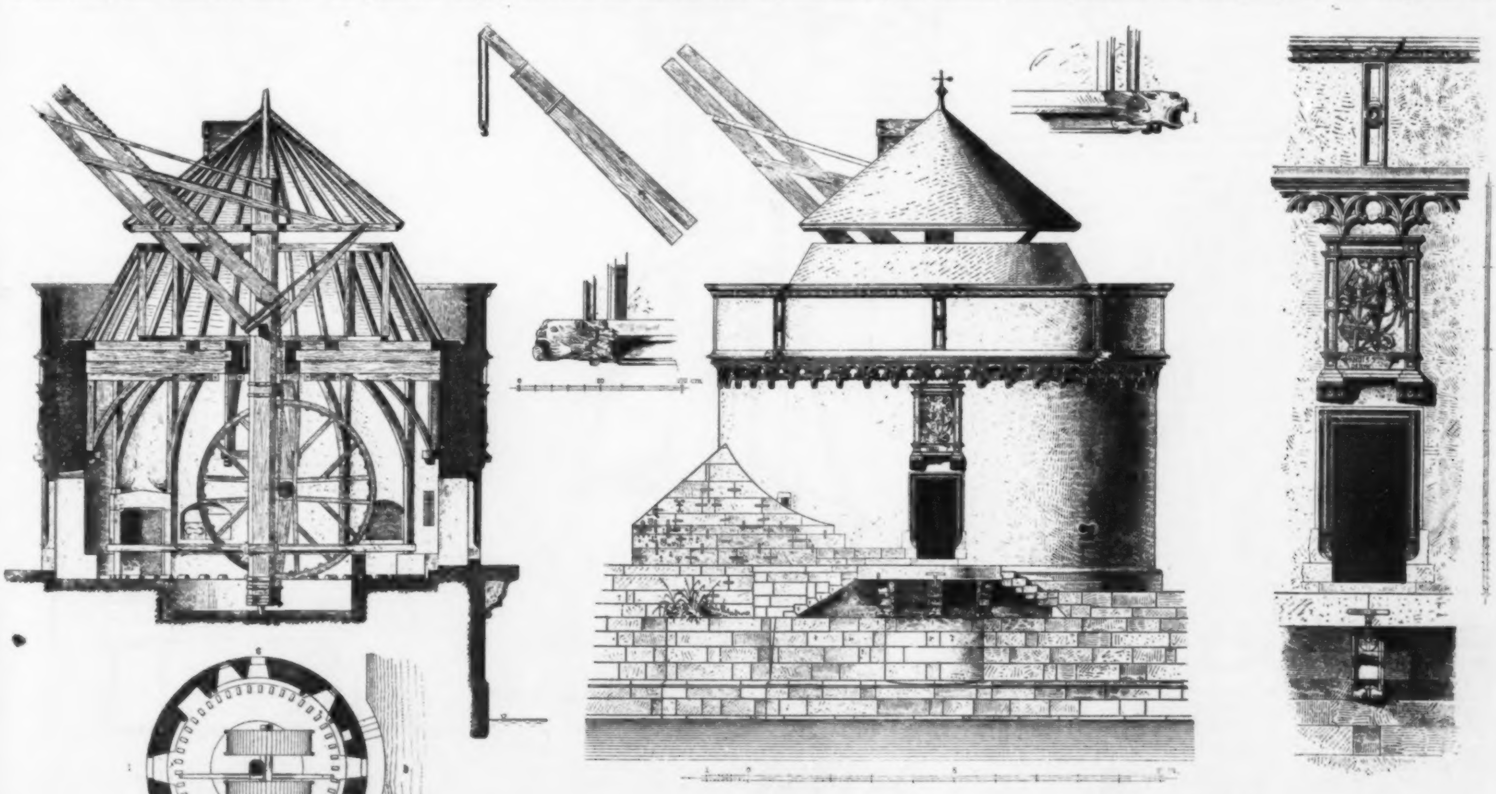
The mechanical construction of the crane is very clever, as will be readily understood by reference to the cross section and plan view. The crane post or mast is set centrally in the housing, and is made of a solid piece of oak, provided at its lower end with an iron point set in a stone step arranged in the foundation; and on the shaft directly below the beginning of the upwardly inclined crane arm or boom is journaled a vertical roller traveling on the inner surface of a ring bearing carried by a well built framework, the posts of which rest on the foundation of the housing. The central post is also provided with a crossbeam extending a suitable distance over the floor, so that men can take hold of the ends of the beam to turn the post, to swing the crane arm and its load around from the land side to the river, and vice versa. The circular floor has raised projections, to allow a good foothold for the men turning the post. The windlass has its drum journaled in suitable bearings carried by the central post, and on each end of the drum is secured a tread wheel for a workman to walk in, to rotate the drum. The hoisting chain extends from the drum upward alongside the post and passes over a pulley upon the crane arm, and along the same over a second pulley, to then extend downward and form the drop outside the housing. The end of the chain is rigidly fastened to the extreme outer end of the crane arm. The latter is about 46 feet long and is made of four solid wooden beams connected by suitable braces with the central post; and the crane arm passes through one side of the conical roof carried by the central post, and the lower edge of this roof extends over the housing roof, made in the form of a frustum of a cone.

The circular wall of the housing is richly ornamented on the outside by a heavy main cornice, an attic divided into fields, and provided with a crowning cornice. The two doors, a b (see ground plan), are located diametrically in the wall, one door leading to a stone platform extending somewhat beyond the quay wall over the level of the river, and from the sides of the platform steps lead downward to the quay wall. Two window openings, c d, are arranged in the wall between the doors, and three smaller openings are provided, presumably for the purpose of enabling the master standing on the outside of the building to give orders through the openings to the men in the wheels or on the beam. A chimney flue is also built in the wall.

The ornamentation over the door on the Rhine side of the building shows a finely sculptured winged female figure holding the coat of arms of the city of Andernach, namely, two crossed keys on a quatered shield. A similar ornamentation is over the door on the land side, but the coat of arms is here carried by two amorettes. The cornice, attic and door ornamentation, together with the beautiful waterspouts, relieve the monotony of the otherwise bare outer surface of the wall.

At one side of the building is arranged an ice breaker for protecting the wall against heavy ice, but this breaker apparently was built at a later period, presumably about 1604.

The crane is still used to-day in the same manner as when it was built more than three hundred years ago. Heavy mill stones brought from the neighborhood of Andernach are loaded by the crane into the Rhine boats at the present time.



A REMARKABLE OLD CRANE ON THE RHINE.

THE LAMBERT WATER METER.

IN most houses there exists but one water meter, and the owner divides the total expense among the tenants in adding to the rent a sum fixed by contract for the annual consumption of each apartment. This system, although common, is capable of being improved upon, since the quantity of water consumed from one household to another, and even from year to year by the same household, is exceedingly variable. It would be much more rational and equitable to make each one pay only for what he actually uses; but, to do this, it would require a separate meter for each apartment.

The apparatus shown in Fig. 1 seems to us to supply a want long felt in this direction. It may be constructed of very small size, while leaving nothing to be desired as to its operation. It was devised by M. Lambert, a Frenchman, residing in New York. It consists essentially of a bronze chamber, C, formed of two shells in the shape of truncated cones, superposed by their

FIG. 1.—THE LAMBERT WATER METER—EXTERNAL VIEW AND DETAILS OF THE DIAL TRAIN.

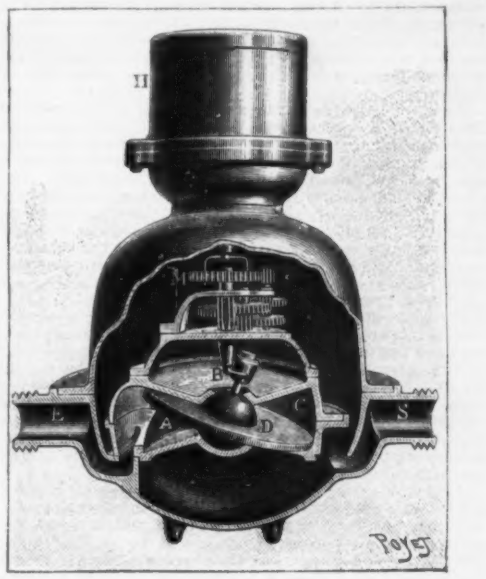


FIG. 2.—DETAILS OF THE MECHANISM.

large bases. Within these there is an ebonite ball to the circumference of which is affixed a disk, D, of the same material. A radial mortise in this disk embraces a diaphragm that forms a vertical partition in the chamber. The water entering through the orifice, E, and making its exit through S, has the effect of a wedge that acts between the walls of the chamber and the disk, which, under such action, begins to oscillate without leaving the walls.

This motion is very curious and very interesting to observe. The advantage of this piston disk is that it displaces a comparatively large volume of water and at the same time permits of a continuous discharge. Since the inlet and outlet orifices are always widely open, there is no obstruction due to foreign materials carried along. A very feeble force permits of setting it in motion and it is capable of operating even with the slight pressure of illuminating gas.

Upon the sphere, and at right angles with the plane of the disk, there is an axis which is carried along with it and the extremity of which describes a cone. A wheel placed at this extremity carries along with it a bent axis, B, that terminates a train of wheels, M, so arranged as to increase the motive power of the disk, and transmit to the dial train, H, the stress produced in the apparatus, even by a single drop of water.

This dial train, which is represented apart and in detail in Fig. 1, acts upon disks placed parallel with each other and carrying figures upon their circumfer-

ence. The number inscribed is thus much easier to read than with a series of small dials.

The apparatus operates very regularly and with the same accuracy in all positions.—La Nature.

DIESEL'S HEAT MOTOR.

It is now a little over forty years ago that Redtenbacher, the great German authority of his day upon the principles of the steam engine and applied mechanics, wrote to his contemporary Zeuner: "The principle of the production and utilization of steam is false. In a future which I trust is near at hand, steam engines will disappear after one shall have merely explained the questions as to the essence of steam and its action."

These prophetic words are beginning to receive their fulfillment, at least in some measure It is a fact which is beginning to be pretty generally realized that the steam engine, in spite of the splendid service which it has rendered since Watt first made it practicable, and the great advance which has been made in its construction, especially of late years, is a most extravagant machine. In the process of burning fuel in a boiler furnace to produce steam, and expanding the steam in a cylinder to secure useful work, only a small percentage of the energy stored in the coal is available as power on the shaft.

Both theoretically and by actual test it can be shown that a high pressure steam engine of the common type and the smaller sizes utilizes only from 4 to 6 per cent. of the energy contained in the coal. If we test an up to date Corliss engine, we shall find only 8 or 9 per cent. of the energy accounted for; and if we take one of the largest multiple expansion engines with the best modern improvements in condensers, cut-off, etc., the best return will be from 12 to 14 per cent. of the energy contained in the coal.

The causes of this enormous loss are well known. There is a loss in the furnace through imperfect combustion, resulting in the emission of smoke from the smokestack. There is a further loss due to the impossibility of absorbing all the heat from the gases before they pass to the uptake, where in some marine boilers their temperature has been sufficient to render the base of the smokestacks red hot. There is an enormous loss due to the latent heat of evaporation—heat absorbed in the effort to turn water at 212° F. into steam at the same temperature. This heat is never, in the simple high pressure engine, returnable as work on the engine shaft. There is a further loss by condensation and reevaporation in the engine cylinders, and a general loss at all points of boiler, engine and steam pipe connections by condensation and radiation.

An important step in the direction of economy was realized when the internal combustion motors were introduced. These, whether using gas or oil, abolish the steam boiler altogether and develop the energy of the fuel within the cylinder itself. The fuel is first introduced into the cylinder, then compressed by the return stroke and ignited. The combustion is so rapid as to amount to an explosion, and the initial pressure is much higher than that in a steam cylinder. With these motors an efficiency of about 20 per cent. is realized under favorable conditions.

A further improvement, marking an advance as important in its way as that of the internal combustion motors over those using external combustion, has been made by Mr. Rudolph Diesel, of Munich. The experiments which led to the construction of the present successful machine, which is known by the name of the inventor, began in 1882, and the conditions which govern the machine were fully formulated in 1893. In the ordinary forms of gas or oil engine the charge is ignited by a jet, hot tube or electric spark, and as we have stated, the combustion is so rapid as to be practically explosive. In the Diesel motor the igniting spark or jet is dispensed with altogether, and the temperature of ignition is secured by the compression of pure air. After the air has reached the temperature of ignition of the mixture through compression, the fuel is introduced gradually into the cylinder and is burnt steadily during the stroke of the piston. The result is that the combustion is effected at a practically constant temperature.

We present five views of a 20 horse power Diesel motor which was tested early in 1897 by Prof. Schröter, of the Polytechnic School of Munich, when an efficiency of 34·7 per cent. was realized.

RUDOLPH DIESEL.

The motor consists essentially of an air pump, a compressed air reservoir, an expansion cylinder, a fuel injector actuated by a small pump, and valves for controlling the pump, reservoir and the expansion cylinder. The pump compresses air into the reservoir, L, at a pressure of between 500 and 600 pounds to the square inch. This pressure is transmitted through the pipe, S, to the injection chamber, D. The fuel, kerosene, is injected into the same chamber by means of a small pump. The injection of the fuel is controlled by an injection needle valve, which rises under the action of a cam during the period of combustion. The duration of the admission, the beginning of the injection and the pressure in the cylinder, L, may be modified

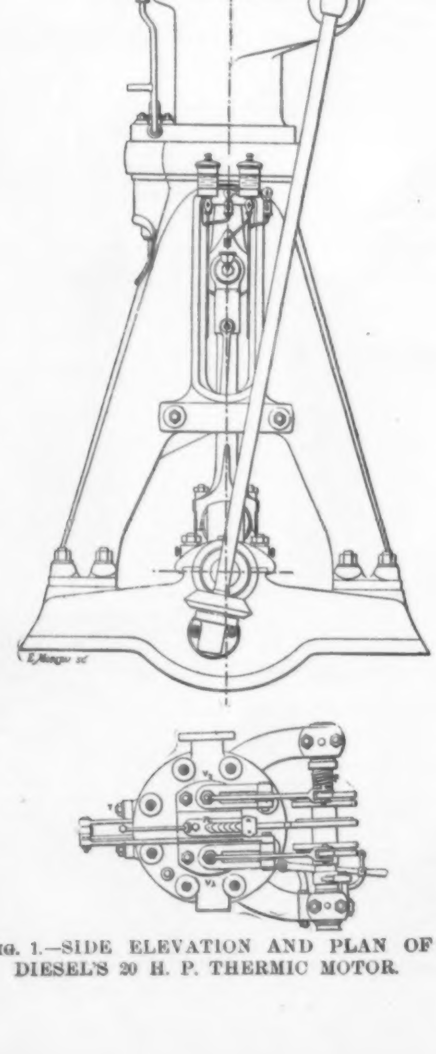


FIG. 1.—SIDE ELEVATION AND PLAN OF DIESEL'S 20 H. P. THERMIC MOTOR.

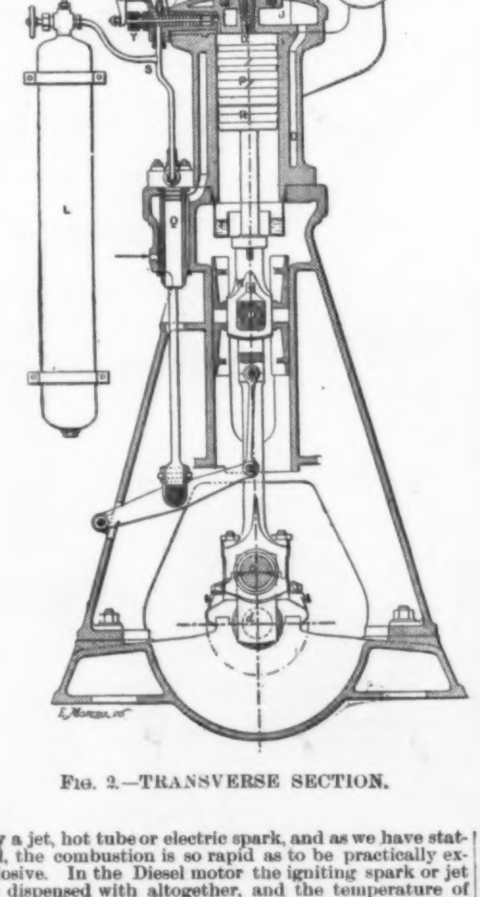


FIG. 2.—TRANSVERSE SECTION.

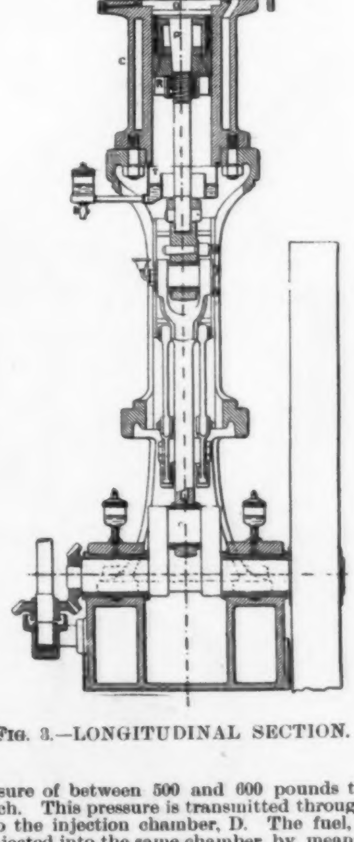


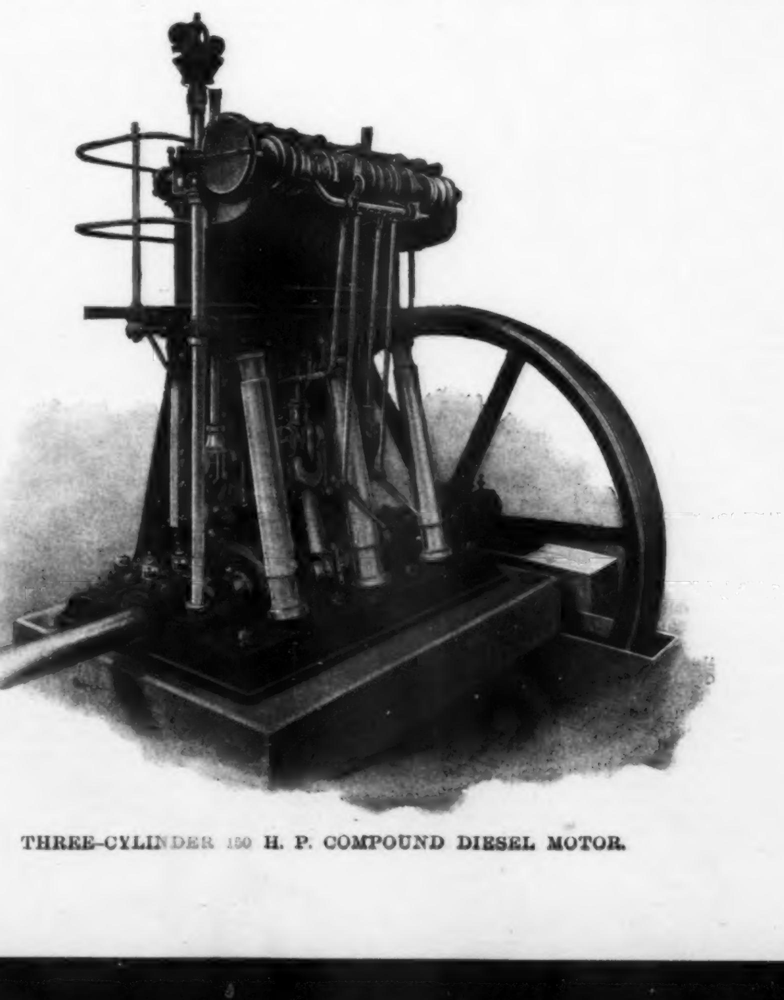
FIG. 3.—LONGITUDINAL SECTION.

according to the power to be produced. The injection needle, the admission valve and the expansion cylinder are controlled by a set of cams mounted upon a shaft near the top of the cylinder, which is driven by bevel wheels on the main shaft and has an angular velocity equal to half that of the driving shaft—a condition required by the four cycle operation of the expansion cylinder. There are five of these cams in all; two of them set the motor in operation through the compressed air contained in the reservoir and three others operate during the running of the motor. The movement of a lever shown in the plan of the motor causes the cams to slide upon ignition of the combustible mixture. The compression of the air to about forty atmospheres raises its temperature sufficiently to cause it to ignite the kerosene which comes into contact with it gradually during the stroke of the piston. The explosion is prolonged, the expansion is isothermic and the combustion, on account of the excess of air contained in the cylinder and its high temperature, is perfect. In addition to its high economy, the Diesel motor has the advantage that the power is easily regulated by acting upon the fuel injector, and the running at a variable charge is done without any break, since the compression always raises

ONE-CYLINDER 20 H. P. DIESEL MOTOR.

the shaft and places them in gear for starting or operating. In starting, the two cams above mentioned put the cylinder in communication alternately with the valve, V_1, which admits the air under pressure, and with the exhaust valve, V_2. When the pistons acquire sufficient velocity the controlling lever is thrown over, causing the cams to slide along on their shaft and assume a position corresponding to the four cycle operation. The starting cams are now out of service; of the other three, the first admits air coming from the pump through the pipe, S, the second operates the fuel injection valve at D, and the third the exhaust valve, V_2. The cylinder is cooled by means of a water jacket and it is lubricated by means of an annular reservoir, T, filled with oil, into which the lower half of the piston dips at the bottom of its stroke. From this brief description it will be seen that in the Diesel motor there is no vaporization and no special the air to the temperature of ignition of the mixture. The motor is always ready to be started, and, as the combustion is perfect, there is no fouling of the interior of the cylinder and the odor of the exhaust gas is practically imperceptible.

We also show a perspective view of a later and much more powerful motor, with three cylinders, which is rated at 150 horse power. It works with compound compression and compound expansion and is now running in the works of the Augsburg Machine Company, Augsburg, Bavaria.



THREE-CYLINDER 150 H. P. COMPOUND DIESEL MOTOR.

ALUMINUM INSTEAD OF STONE.

Of the many uses which have been found for aluminum in recent years, probably the utilization of the metal in the graphic arts is at the present time attracting the most attention. It has now become evident to lithographers that aluminum is bound to replace stone in the art of surface printing, and there is a general movement among the trade to learn the latest and best methods of treating and handling aluminum plates. As this art of printing has developed, The Aluminum World has chronicled the progress made by the different lithographers, and, as our readers are aware, there are two distinct processes of aluminum plate printing in successful operation. One, known as the Ellery-Howard, is of American invention, has been described a number of times in these columns, and is being used very successfully for all classes of work by the Orcutt Company, of New York.

The other process, known as the Strecker-Scholz, was invented in Germany, and is now being introduced into several lithographic establishments in the United States. While the methods of treating the plates differ in each process, the objects of each are the same, which is to utilize a cheaper, quicker and handier material for surface printing than can be attained with the use of stone. By the use of an aluminum plate on a rotary press the number of impressions which can be run off in an hour is about twice as many as in the flat bed press. This is the present experience of lithographers who are using the plates, and as they become more accustomed to the new material they hope to print with even greater rapidity. The National Lithographer, in commenting recently on the Strecker-Scholz process, and aluminum instead of stone, said:

"The use of aluminum as a substitute for lithographic stone has lately occupied the attention of many lithographers. Repeated attempts have been made to use it both in Germany and this country, but not until the present time has the high standard of perfection of litho stone work been reached. From what we learn and to judge from the samples shown us, the problem has been solved by means of the Strecker process, and the introduction of the new process will now be pushed by one of the most enterprising supply houses in this country.

"A short time ago a syndicate, under the style of the Strecker-Scholz Company, was organized for the purpose of purchasing from Joseph Scholz, of Mainz, Germany, the letters patent for the United States, issued to Dr. Otto Carl Strecker for the preparation of the aluminum plates for lithographic printing. We are told that process has at last produced a printing surface combining the lightness and other advantages of the metal with the excellent qualities of lithographic stone, which the aluminum in itself lacks.

"The process consists of the creation on aluminum plates of a new surface by the application of certain chemicals and processes.

"The Strecker process is now in successful use in many establishments in Germany and in France, Italy, South America, and is now being introduced in England, and more lately, New York City. The original owner of the process, Joseph Scholz, has an establishment at Mainz, Germany, fitted up entirely for lithographing and printing by this process. This concern retains its control for Germany and is engaged in the further business of granting licenses. The entire rights for France have been sold by them to Lemercier, one of the largest and oldest lithographic establishments in Paris. The rights for the United States and Canada were purchased by the Strecker-Scholz Company, and the exclusive control of the sale of licenses and materials has been acquired by the Fuchs & Lang Manufacturing Company. A license has been granted to the J. Ottmann Lithographing Company, and that company has been successfully operating under the same since last July. Another license has just been granted to the Sackett & Wilhelms Lithographing and Printing Company, of New York.

"Both the Ottmann and the Sackett & Wilhelms companies are now running a large number of presses with excellent results, as shown by samples of work printed exclusively from aluminum in those establishments. The Strecker process renders the plate fully equal to lithographic stone in the quality of the work, while promising great advantages of economy in the handling of the plates for flat bed presses, and greatly increased speed in the case of rotary presses for which stone is impracticable.

"The consequent introduction of improved rotary presses, capable of doing work from the Strecker plates, at least 75 per cent. faster than a flat bed press, will, if successful, open up a new and vast field for lithography, and enable our industry to regain all it has lost through the competition of the relief printing press in connection with the three-color process. Rotary presses already built and operated are capable of doing work by the Strecker process 50 per cent. faster than from flat bed presses, and from what has been shown us we can say that the quality of it is fully equal to the average production of the flat bed press.

"The use of the Strecker plates for flat bed presses requires no change from the present machinery, with the exception of the substitution of an iron bed for the stone. On three new No. 5½ presses just now being put into the establishment of the Sackett & Wilhelms Lithographing Company, by R. Hoe & Company, the clamping apparatus has been made a fixture on the sides of the stone bed, an iron bed taking the place of the stone in same. The plate is to be stretched over the iron bed and held by clamps on both sides of the box. The first trial of this new arrangement resulted in the adjustment of the plate for printing in fifteen minutes.

"It is claimed that a plate can used an indefinite number of times by the Strecker process, being therefore practically indestructible. Joseph Scholz claims to have used a plate for more than one hundred transfers, and still uses it. The mere item of rent for the storage of bulky lithographic stones is a very large one in cities where rents are high. This item of expense becomes infinitesimal in the case of the Strecker plates, whose lightness and small bulk render very small space sufficient for the purpose of their storage. The cheapness of the plate will enable lithographers whose work has any permanence to file away large drawings and even transfers on Strecker plates, where, in the case of lithographic stone, this course would have been prohibited by the price of material and expense of storage.

"Under the Strecker patent for graining aluminum plates a perfect substitute for the lithographic grained stone is obtained, and we are informed that the artists

employed in the establishments using the Strecker process always prefer this material to stone, as the grain is much sharper and accepts the crayon more readily.

"We think that the Strecker process is designed to revolutionize the lithographic trade, and advise all lithographers who do not wish to be left behind, to make themselves familiar with the new method without much delay."

Besides the firms mentioned as using the Strecker-Scholz process, the Providence Lithograph Company, of Providence, R. I., has also introduced this process in the company's Huber rotary zincographic press, and when so used has changed the name of the press to aluminographic.—Aluminum World.

THE MAKING OF PORCELAIN INSULATORS.*

By F. A. C. Perrine, D.Sc.

By most writers on the subject, the material of porcelain is considered to be one of the two great divisions of ceramic ware, and it is distinguished from pottery by being more dense, whiter and less fusible, but particularly in being translucent. Indeed, many consider that translucency is the only means by which porcelain may be distinguished from pottery. Pottery is a ceramic ware moulded from a paste of impure hydrated silicate of alumina, containing certain amounts of free silica, lime and iron. The product is opaque and invariably porous, on account of the removal of the volatile ingredients in the baking process. Porcelain, on the other hand, consists principally of a pure silicate of alumina only slightly hydrated, called kaolin, inclosed within a matrix of hard silicate glass. In the oldest history of the art the Chinese found pure kaolin in certain clay banks, and in other banks the ingredients for a silicate glass, which, being mixed together, moulded and baked, formed what is called "natural" or "hard paste" porcelain. This was first imitated in Europe by "soft paste" porcelain, an admixture of the kaolinic clay with an artificial glass composed of a mixture of niter, soda, gypsum and salt, the proportion of kaolin to the glass being much less than in the natural Chinese product. Between these two lie the "mixed" or "bastard" porcelains, which are uncertain in character, but which are all composed of kaolin inclosed within a bond of more or less fusible glass. To this last class belong most of the American porcelains, although some of our potteries produce a material more like pottery than porcelain in porosity by mixing the ordinary grades of pottery clay with kaolin. When first baked, all of these materials are more or less imperfect over the surface, having much roughness and little luster, which surfaces must be finally protected by a subsequent glazing, the glaze consisting of nothing more than a thin coating of glass, which may be merely and entirely an artificial glass similar to that from which bottles are made, or a natural glass made by melting over the surface a powder of pure feldspar. We see then, in the first place, that the character of the insulating material depends upon the clays used and the percentages in which they are used, since by changing the ingredients we may pass from glass, which is melted and runs at a temperature a little above the red heat, through soft paste porcelains and mixed porcelains to hard paste porcelains, which in the hardest grades cannot be melted at a temperature below 2,000° Fah. Pottery can hardly be ranged in this series, nor is it proper to range here the so-called porcelains containing pottery clays, for the reason that the materials from which these articles are made all contain substances of a volatile character, and furthermore, these clays are deficient in fusibility, so that the ware is necessarily porous on account of the volatilization of water and other contents of the materials as they are moulded before baking.

The general process of manufacture of the insulator for an electrical line follows closely the processes that have been used in the manufacture of porcelain since the earliest times, with one important change, which is the result of modern inventive methods. The clays used are intimately mixed by grinding under water into a perfectly homogeneous mass, and after the superfluous water used in grinding has been removed by settling or filtering, the clays are moulded into shape required for the finished articles by either "casting," "throwing" or "pressing." The operation of "casting" is the one by means of which we obtain thin eggshell china so much admired in our dainty teacups. For this purpose a mould of plaster of Paris is furnished, which determines the outside shape of the article to be made. This mould is filled with a so-called "slip" of clay, about the consistency of cream; the plaster mould immediately absorbs the water and holds on its surface a layer of clay, the thickness of which is determined by the time the slip is allowed to stand. When the articles are thick enough, the remaining slip is poured out, the surface smoothed by a delicate touch or two and the teacup is ready for drying and baking. Larger and thicker articles have from time immemorial been "thrown" on the potter's wheel. For this work the slip of clay is settled and filtered, and the remaining mass of wet clay moulded and dried until the correct plasticity is obtained, when it is taken by the potter and whirled upon his wheel, while with his hands he guides the jug into the shape desired.

Modern invention has almost superseded the potter's wheel by the potter's press, and by this press the tough, hard paste porcelain can be made in thick objects without porosity, as was formerly only possible with glass and soft paste material. For working in the press and to obtain a material of great density, the damp clay is further dried until it is in a powder which will not adhere in masses except under considerable pressure. This powder is then filled into a matrix and a core brought down; the sharp pressure consolidates the clay into the form of the finished article, the density of the resultant baked porcelain depending not only upon the proportion of the ingredients, soft and fusible, but also upon the amount of pressure applied; since as the pressure is increased the clay may be more thoroughly dried and smaller spaces left by evaporating moisture. Moisture cannot, however, be entirely eliminated from clay until it is subjected to the heat of a pottery kiln, and that this process removes a very considerable amount of water from the mass is shown by the fact that the shrinkage in baking amounts to about as much as the shrinkage in the cooling of cast iron, namely, a shrinkage of one-eighth in the linear dimensions. The spaces remaining are filled in the baking process by the fusible material with which the kaolin is mixed.

Whether "cast," "thrown" or "pressed," the articles made from clay are of consistency not different from that of a lump of clay until subjected to the heat of a pottery kiln, when the water of hydration is driven off from the silicate of alumina and any glass contained in the mass is fused, thus rendering the finished baked porcelain article hard and solid, the hardness and toughness depending largely upon the quantity and quality of silicate of alumina, while for the solidity we must look to the presence of a certain amount of fusible glass. The proper porcelain, therefore, for insulation is that in which there is only that amount of glass present which is necessary to fill up the porosity of the dehydrated silicate of alumina, since when this proportion is attained the greatest amount of strength consistent with non-porosity is reached. Should the amount of glass be increased beyond this point, the porcelain will become brittle, although it will still be nonporous—but nonporous just as glass is nonporous—and hence without the advantage over ordinary glass supposed to be possessed by a hard paste porcelain. If the amount of glass present is only so much as will fill up the pores left by the escaping water as the silicate of alumina is dehydrated, we can readily see that such porcelain has no property by means of which wide cracks in the moulded clay can be stopped up, since at no temperature available within the pottery kiln will the mass fuse and run. We may say that the glass is drawn by the porous silicate of alumina into itself by capillary attraction, and when spaces are present which are not capillary these spaces cannot be filled up; accordingly, we see that the solidity of the finished article in hard paste porcelain manufacture depends upon the solidity of the moulded clay, and we also see that it is erroneous to suppose that while the porcelain manufacturer can make thin articles which will be solid, it is impossible for him to obtain an equal solidity when heavy masses are dealt with. It is, indeed, more likely that the heavy articles will contain open spaces than that the latter be present in thin pieces, since whether the pressure is applied on the wheel by the hand or in the matrix by the die, it is easier to make solid a thin layer of the clay than a thick one, but at the same time that porcelain manufacturer who does not increase his pressure sufficiently to insure the solidity of thick pieces is not handling his clays properly, and the fact that certain makers are not able to produce heavy solid articles does not tend to prove that solidity is an impossibility where the clays are properly handled.

Another danger must also be avoided in the choice of a porcelain insulator of great weight, which is harder to detect than the presence of porosity, since the exact knowledge of the mixture of clays used is only possessed by the manufacturer himself. I am speaking now of the tendency toward the use of soft paste porcelain by manufacturers whose machinery is not powerful enough to compress the hard paste clay to a sufficient density for a perfectly solid heavy insulator. Of course, with what has gone before, we can at once see that, should a manufacturer find that his mixture in heavy masses does not give a thoroughly solid product, he can at once add more glass, or glass of a more fusible character, reducing the amount of kaolin, on which we depend for strength. He will then obtain great solidity at the expense of toughness and strength. This is an error in the manufacture of insulators which can only be detected with the greatest difficulty, since the highest experts on porcelain wares are often at a loss to determine whether the body of an article is a hard or a soft paste porcelain without determining the crushing strength, and of course a mechanical test is exceedingly difficult to apply to such an irregular body as a line insulator. Even the chemist is here upon ground in which he is not sure, since the differences between the clays and the glasses are chemically so slight that the result of an analysis is of very little worth. While this is undoubtedly the greatest difficulty in the matter of insulators for withstanding high potentials and carrying lines of great weight, it is the point in which the manufacturers are deficient in their apparatus, since there is hardly a factory in the country which is equipped for pressing the heavy high voltage line insulator more solidly than articles much smaller are necessarily pressed, and, in consequence, it is probable that at the present time most of the manufacturers make an insulator which is either porous in a heavy body of the insulator head or that a much softer paste is dealt with than is used for smaller articles.

Should a manufacturer attempt to mix and press a hard paste clay which shall give a thoroughly solid line insulator of the greatest size, he would also encounter the difficulty that clay when pressed is not a liquid body, and in consequence pressure applied in one direction is likely to produce cleavage lines in the insulator, and in consequence we may not at the present time say that insulators of the form now used can be made solid from dry hard-pressed clay without danger of the production of such cleavage lines, and in consequence we must use a softer paste until the proper form of insulator shall be developed, or perfect the moulding of the hardest paste used in the driest possible state and sufficiently hard pressed for complete solidity after baking. These cleavage lines are especially apt to occur where irregularities in pressure are sustained by the mass of clay in moulding. That such irregularities must almost inevitably occur will be evident to one who examines carefully any insulator with long thin petticoats; and furthermore, this same examination will point to a danger of the petticoat splitting away from the head of the insulator in baking, when, as has been said, the shrinkage of one-eighth occurs. The effect of this shrinkage is well known to ironmoulders, and no competent patternmaker would attempt to join long thin plates to a heavy body without in some way taking care of their tendency to split away from each other when shrinkage occurs. In consequence, the most successful designers of articles for manufacture in pressed porcelain are those who have had thorough training in moulding complicated cast iron shapes. Whether the petticoats are broken away from the mass of the insulator in pressing or in shrinking when they are baked, we find that most of the failures of such insulators when pierced by high voltages occur along cracks which are found in the porcelain at about the point where the petticoat is joined to the heavy head. Coming from the kiln, articles made of hard-pressed porcelain, however smoothly moulded and however solid in the interior, are found to have a surface which is dull and somewhat rough, and where a smooth, shiny surface is desired, glaze must be applied. Glaze is a glass applied to the exterior surface of the baked porcelain and fused on by subsequent baking. The glaze is perfect when it flows evenly over the surface of the article, and when it does not crack on coming from the kiln, or subsequently when exposed to varying temperatures. Cracking of the glaze is technically termed "crazing," and crazing is due entirely to a difference in the coefficient of expansion between that of the glaze and that of the underlying porcelain biscuit. It would seem at once to be the most reasonable proceeding to glaze our porcelain biscuit with the material of its body; but if this body is that of a hard paste porcelain, it is not sufficiently fusible for use as a glaze, and in consequence the surface must be covered with something more fusible. Accordingly, the selection of a glaze which shall have the same coefficient of expansion as that of the porcelain body is a matter of the greatest difficulty. This difficulty increases as the thickness of the glaze is increased, on account of the fact that while a thin glaze may have sufficient elasticity to give with movements of the underlying porcelain, a heavier body of glaze will not yield so readily.

That this should be true is apparent at once by the examination of a glass thread, which can be bent and even woven, while the glass rod from which it is made seems to be almost absolutely rigid. Tiles have been made with a glass face as much as one-sixteenth of an inch in thickness, but this was accomplished only after a long series of experiments, with repeated failures, and only on the surface of a rough tile made of porous fire brick. The natural hard paste porcelain of the Chinese is supposed to be glazed with pure feldspar, but a more readily fusible glass is required by almost all the European and American porcelains, while for each porcelain body a different glass is required; and not only is there probably but one glass which will glaze a particular porcelain, but also that porcelain manufacturer is to be congratulated for the care and success of his research after he has found a glaze which under no circumstances of changing temperature will craze. Josiah Wedgwood spent many years of his life in ascertaining this fact and in determining the proper glazes for his different wares, while in this country thousands of dollars have been consumed by the different porcelain manufacturers in finding satisfactory glazes. In many cases such glazes have not yet been found, and in consequence but very few of our porcelain manufacturers can make a satisfactory line insulator without a crazed surface. That we should require a surface which does not craze is due to the fact that, although we do not depend upon the glaze itself as an insulation, we do depend upon it for preventing the retention of moisture upon the surface of the insulator. The nonhydroscopic character of porcelain as compared with glass therefore depends upon the character of the glazing surface and also upon its mechanical perfection. There is here a danger in the use of some porcelains, that while when made the smooth glaze is nonhydroscopic, the glass necessary to use for glazing will be soluble, and when weathered will present a rough surface, even though no crazing should ever occur. Indeed, it is probable that all porcelain glazes will ultimately weather, since the hardest glass we know of is that made of pure feldspar, which, even a slight study of geology tells us, is destroyed by atmospheric influences, and this is an additional reason for turning our attention from the glaze to the porcelain body when we speak of insulation resistances; and even were this weathering of the glaze removed to a remote possibility, we do know that any glaze will be worn away from the insulator by the contact of the line wire which the insulator is destined to support.

Having now examined carefully the necessary details in the manufacture of porcelain for insulators, we are prepared to give some guide for the writing of proper specifications and the pointing out of tests which should be made upon a porcelain insulator in order to obtain the best product that our manufacturers can at the present time produce. It is useless for the engineer to attempt to limit the porcelain manufacturer to certain pastes or glazes, since the clays used by different makers, though bearing the same names in different parts of the world, are not at all the same in ultimate character—one or two per cent. difference in the amount of water contained by the kaolin changing the whole character of the mixture necessary in the production of hard porcelain. And, as we have said, a different glaze is required for each mixture of clay; therefore these details must be left entirely to the manufacturer himself, since he is better able to make the choice necessary for a successful product than any engineer, no matter how carefully the latter has studied the use of insulators and the manufacture of porcelain. But, at the same time, the user should endeavor to ascertain which manufacturer uses the strongest paste and produces the densest insulator. Strong pastes can be chosen from soft pastes by mechanical tests alone, and the ability of the insulator to withstand shocks as well as pressure should be carefully tested.

In applying electrical tests it seems foolish to attempt only tests upon the finished glazed articles, since if the glaze is perfect it will completely mask the most serious extent of porosity, and even twice the potential of the line may not pierce a defective insulator, which will fail during the first rainstorm after the glaze has been worn away by the wire. The proper time, therefore, to apply any electrical test to the porcelain insulator is while the insulator is in the biscuit and before it has been glazed. It is always perfectly easy to test for porosity and to stamp the accepted insulators under the glaze by a mark which cannot be counterfeited after glazing has been performed. Even a galvanometer test at moderate potentials in this stage will furnish more accurate knowledge of the state of the porcelain than a high potential test after the glazing has been applied. Especially is inspection at this time important, as the glaze will mask cracks as well as porosity, which cracks would be apparent to the eye of the inspector before glazing, although completely covered by skillful work in the glazing process. The final inspection of the finished insulator should turn upon the perfection of the glazed surface, although it is foolish

* An abstract from an article in Electrical Engineering.

to attempt to obtain an insulator glazed in every part, since the insulator must be carefully supported in the glazing furnace, and where it is supported the surface will remain rough. It is indeed possible to specify the position upon the insulator of this rough surface, but one cannot expect to obtain a piece of porcelain covered with glaze in every part.

Finally, it should be pointed out that the relative positions of the wire and the petticoats demand some study, since if the petticoats are likely to be cracked away from the body of the insulator at their point of attachment with the head, it seems wise to remove the wire from this danger point as far as possible, although, of course, actual contact of the wire with a crack is not necessary for piercing through that crack, since the high potentials now used will leap along the surface of an insulator from three to five inches, and, in consequence, if the path from wire to pin through a crack is less than the sparking distance of the potential used, leaks will occur through a crack even though neither pin nor wire be in contact with it.

It certainly seems, therefore, that, although we may improve our present insulators by a careful study of their material and form, it is at present unnecessary to attempt any redesigning of the insulators in use until we have thoroughly tested the capabilities of our porcelain manufacturers to produce insulators of the present form which shall be sufficiently strong to carry the wire and sufficiently solid to prevent the escape of electricity through the body of the porcelain without reference to the character or existence of glazing.

SOLUBLE GLASS IN HOUSE CONSTRUCTION.

A MATERIAL suitable for rendering walls impervious to dampness and presenting a smooth, close surface is somewhat of a desideratum in house construction. Paints and varnishes to a certain degree have supplied such a want, but with time these materials are apt to deteriorate.

In Europe the use of soluble glass for such a purpose has met with considerable success; its use for fixing mural painting has also commanded the praise of artists.

Properties of Soluble Glass.—For an intelligent and successful use of soluble glass, it is necessary to be acquainted with the properties of this material, so as to avoid the often occurring disappointments and the inability to remedy defects.

When soluble glass is evaporated to a certain degree of concentration a pellicle is formed over the surface of the solution, which, however, on being forced through the mass, is again dissolved. If concentration is carried on to a higher degree, chilling takes place and the mass turns to a jelly.

A diluted solution of potash soluble glass is rapidly decomposed by carbonic acid in the air. Such a decomposition, however, becomes much slower with a solution of 1·25 density. If reduced to powder and left to remain a long while exposed to the air, it cannot be completely dissolved, and effervesces in contact with acids; this is in consequence of absorption of carbonic acid from the air.

Soluble glass, when dried by a moderate heat, gives a vitreous and transparent mass, which can be redissolved completely in boiling water. When sufficiently heated to a low red heat to expel the water completely, soluble glass gives a residuum which is soluble in part in boiling water, abandoning silica, which is separated.

The composition in the soluble part corresponding to $2\,Na.\,O\,3\,Si\,O_3$ would seem to indicate that with a red heat there is no possibility of a combination of the soda with a larger proportion of silica.

An experiment on soda soluble glass has given;

Separated silica		12·47
Soluble part	Silica	32·07
	Soda	15·98
	Water	38·66
		99·18

Soda soluble glass is precipitated from its solution by chloride of sodium, alkaline carbonates, etc. Alcohol also precipitates it under the form of a white flocculent mass, which can, however, be completely redissolved in water. This property gives a means of purifying potash soluble glass from an excess of alkali. As to soda soluble glass, it behaves in a different manner, according to its tenor in silica; alcohol has but little effect and does not precipitate it completely, but simply transforms it into a mucous mass.

With earthy bases—lime, magnesia—also oxide of zinc, a true chemical action takes place in solutions of soluble glass; a part of the silica is precipitated and the precipitate contains alkali. Metallic salts completely precipitate silica; hydrochlorate of ammonia has the same effect and causes ammonia to escape.

A solution of soluble glass mixed with caustic lime assumes rapidly the form of a viscous paste; such a paste, on desiccation, hardens but little, splits up and falls to an efflorescent powder under the influence of an alkaline carbonate.

Pieces of chalk repeatedly immersed in a solution of soluble glass become very hard, without, however, reaching a point equal to marble. Such a phenomenon is solely attributable to the desiccation of the solution absorbed by the chalk, no chemical action taking place.

Soluble glass has a similar action upon most materials used in construction—cut and rough stones, bricks, pottery, etc.—increasing in a certain measure their character, hardness and resistance.

Application of Soluble Glass.—Though soluble glass as a concentrated silica solution has remarkable properties, the manner in which it acts in a double viewpoint, physically and chemically, and its easy preparation have led to the belief that it would find many applications in industry, yet its use has had a slow growth. We owe much of its success to the persistent efforts of Mr. Kuhlman, of France, who has introduced it practically upon a large scale by various processes which he discovered.

Soluble Glass for Fireproofing.—One of the first uses of soluble glass after its discovery has been for fireproofing, and one of the causes that suggested its use was the burning of the Munich theater. In the reconstruction of that edifice soluble glass was used as a coating on woodwork and scenery, as recommended by Fuchs. It must be admitted, however, that soluble glass used for such a purpose on combustible materials has but a limited value. Wood, fabrics, paper, etc., covered with coatings of soluble glass, when submitted to the action of fire, offer but little security. The action of the flames causes a cracking, the coating falls off, the flames reach the inflammable volatile products evolved from the inside and combustion takes place. The same action takes place with other materials.

Soluble glass cannot be used with good effect in connection with an oil color. On several materials, but especially on wood, soluble glass, through its alkaline reaction, produces a brown color, quite deep, causing the disappearance of the natural color. With resinous woods, such as pitch pine, a uniform tint cannot be obtained, many spots appearing; this effect is much less on ash, oak and similar woods. Though the brown tinge imparted by the use of soluble glass mixed with a suitable color may not be of itself an objection, yet in most cases it must be rejected, owing to other considerations. However, wood covered by a coating of soluble glass is in a better condition than with a bare surface, being protected from air and dampness. When a coating of soluble glass is properly applied on wood, it is proof against washing. Applied to paper and cloth, these substances become somewhat stiff, but not sufficiently to prevent rolling; folding, however, or plaiting destroys such a coating.

The only rational way of applying soluble glass is by repeated coatings with sufficiently diluted solutions. A single application of a concentrated solution invariably gives unsatisfactory results.

Silicatization of Building Materials.—The use of soluble glass for the purpose of protecting constructive materials against atmospheric agencies is of much more importance and value than its use for fireproofing. This is of special value in protecting such materials as are apt to scale off in the air or such as cannot resist the effects of outside influences. The beneficial effect of soluble glass in such application depends entirely upon the manner in which it has been applied and to what depth it has penetrated into the materials. This naturally indicates that concentrated solutions are not suitable. From numerous experiments made in practice, it is shown that a solution of 35° B. diluted with twice its volume of water gives a solution adapted to the hardening of stones.

In new houses such a solution can be applied at once, but in old houses the walls should be first thoroughly cleaned with a hard brush or washed with caustic potash. It becomes sometimes even necessary to scrape the surfaces. When large surfaces are to be covered, the injection is produced with pumps having a head to spray the material. Care should be taken to save the drippings, to be used over again.

For carvings and certain parts of buildings soft brushes are used. Experience has demonstrated that three applications on three successive days are sufficient to harden stone properly. The quantity of solution absorbed varies according to the nature of the stone and its porosity; for the most porous stone the expense does not exceed twenty cents per square yard.

When operating on small materials, like brick, when new they are simply dipped into a bucket. With plaster, the action of the soluble glass is very rapid and is apt to give birth to sulphate of potash, which, when crystallizing, has a tendency to scale off. Consequently, in such cases, only diluted solutions should be used, so that the action may be slower; but the combination should be sufficient, however, in order to avoid the crystallization of the sulphate of potash.

It has been objected that by covering walls with a coating of soluble glass their porosity disappears, and the air which can penetrate through ordinary walls is stopped, thereby preventing its renewal from outside. This seems to have little weight, because ventilation that depends upon the porosity of walls must, of necessity, be very small, and modern constructions have provided more certain means. Again, it has been said that the soluble glass coating, though preventing dampness from penetrating from outside, also prevents the inside dampness, which would naturally pass through the walls, from reaching the outside. For the reason just mentioned, this objection has no importance.

The action of an alkaline solution upon porous calcareous stone is slow and accomplishes a gradual hardening on the siliceous molecules. With plaster it is quite different, the action being quite rapid, almost instantaneous, producing quite a swelling on the mass and making it very porous and causing scales to fall off.

Coloring Stones with Silicates.—Soluble glass can be used for imparting to stones certain colors by mixing a coloring agent into the solution. By using certain double silicates, useful applications may be made with good effect. For instance, with the double silicate of manganese and potash, a dark solution is obtained which is recommended for use on too white calcareous stones. By dissolving in a siliceous solution sulphate of baryta, made artificially, a solution is obtained for bleaching stones of too dark a color. The effect is produced by the small quantity of sulphate which penetrates into these stones with silica.

Porous calcareous stones submitted to boiling in metallic sulphates of oxides insoluble in water have imparted to them colors to a certain depth which are entirely set by a combination with sulphate of lime. With sulphate of iron, a more or less red color is obtained; with sulphate of copper, a fine green; with sulphate of manganese, various browns.

Siliceous Painting.—As far back as 1847 Fuchs suggested the application of soluble glass for the preservation of mural paintings. The first application was made by the celebrated painter Kaulbach to the fresco paintings then made in the Berlin Museum. Since then applications have gone farther, and at the present day soluble glass is used as a medium for applying colors direct to walls with a brush.

Since oil and essences cannot be used in connection with soluble glass, it became necessary to find out the colored bases which could be substituted. White lead, having the tendency to form a silicate of lead very rapidly, had to be discarded. Oxide of zinc gives very satisfactory results by mixing it with a strong proportion of artificial sulphate of baryta, producing a very good white of a very bright and transparent quality. Further experiments have demonstrated that this white could be made by sulphate of baryta alone, if applied in successive coatings, by means of a mixture of starch with the siliceous solution.

For all colored mineral matters, it was discovered that all those capable of being altered by alkalies should be discarded. The following can be used: Zinc white, chrome green (oxide of chrome); cobalt green (Rinman's green); chrome red (lead chromate); zinc yellow, oxide of iron (light red, dark red, purple and brown); sulphate of cadmium, ultramarine, ocher (light, skin color and gold ochers); Sienna earth, umber, lampblack, calcined manganese oxide, etc. It was also discovered that colors ground in a concentrated solution of silica can be applied more regularly upon stones which have been silicated than those that have not been subjected to this treatment; in the latter case, it is advisable to impregnate the surfaces with a weak silicate solution.

The use of soluble silicates has given birth to a new style of painting, destined to replace the old style of fresco painting known under the name of stereochromy. The main object of this process is the protection of mural painting from the action of its dread enemy efflorescence. Its importance is especially great in protecting such paintings as are exposed to atmospheric influences, to rain and air, when painted on outside walls.

Experience has demonstrated that for a proper foundation or grounding for the preparation of the coloring elements and their preparation with soluble glass, it requires many studies and care in manipulation to insure satisfactory results.

For a grounding, mortar may be used, but care should be taken to let it dry thoroughly and absorb a sufficient quantity of carbonic acid to transform the hydrate of lime into carbonate, thus preventing any further action upon silicates. A ground can also equally be prepared with a mortar of soluble glass, i. e., a mixture, in suitable proportion, of dolomite in powder, of pulverized quartzose and pulverized and soluble glass. The colors are to be applied upon this ground, which should not be either vitreous or polished, but should remain sufficiently granular and susceptible of being impregnated.

It must be said, however, that soluble glass used as a medium for applying colors has some drawbacks; it is preferable to substitute pure water and simply use it for setting colors after being applied.

Ordinary soluble glass saturated with silica as much as possible has a tendency to cloud the painting and produce spots, on account of the partial decomposition resulting from contact with the air. For this reason a glass should be used not being saturated with silica, as stated before. A solution obtained by a mixture of four to five parts of a concentrated solution of soluble glass with a dissolution of flint liquor, also concentrated (one part carbonate of soda and two parts pulverized quartz), is called the setting soluble glass.

The following mode of operation gives very good result in applying colors:

The first coat, or grounding, is put on with a lime mortar, and should not be used until the action of the air during a few days has made it dry and it has absorbed carbonic acid; cover then with soluble glass with a soda or potash base. When this grounding has solidified, the upper coating for receiving the painting should be put on. This coat should be about one-eighth of an inch thick and be as smooth as possible. When dry it should be made even, by rubbing with a sandstone, to remove the small skin of carbonate of lime, formed while drying, as this would prevent the absorption of the solution of soluble glass, and also to give to the surface the desired hardness.

When the bottom coat is quite dry it should be impregnated with soluble glass, in order to give it the proper consistency and unite it to the subjacent coating. The colors are now applied upon the outer or upper coating, by means of pure water, which is sprinkled upon it frequently. The colors being applied, there now remains the operation of setting them. This is done with the so-called setting solution, described before.

Owing to the fact that the colors adhere but slightly, preventing the use of a brush, this solution is projected upon them by means of an atomizer in the shape of a mist or a fine powder. When the colors are set the painting is finished, but it improves the appearance and insures the permanency to wash the walls with wine spirits two days after.

Colors for stereochromic painting when applied in this manner have a soft and bright appearance which cannot be obtained by the old style of fresco painting. —C. Colné, in The American Architect and Building News.

TO MAKE LACE LEATHER.

AN expert, in Hide and Leather, gives the following instructions, which may be useful to those interested in procuring good lace leather at reasonable cost:

Take cow hides averaging from 25 to 30 pounds each; 35 hides will make a convenient soak for a vat containing 1,000 gallons of water, or 25 hides to a soak of 700 gallons.

Soak two days or more, as required. Change water every 24 hours. Split and flesh; resoak if necessary. When thoroughly soft, put in limes. Handle and strengthen once a day, for five or six days. Unhair and wash. Bathe in hen manure, 80 degrees temperature. Work out of drench, wash well, drain four or five hours. Then process, using 45 pounds vitriol and 600 pounds of salt water to 700 gallons of water. In renewing process for second or consecutive packs, use 15 pounds vitriol and 200 pounds salt, always keeping stock constantly in motion during time of processing. After processing, drain overnight, then put in tan in agitated liquors, keeping the stock in motion during the whole time of tanning.

For tanning use a gambier liquor of 4 to 6 degrees strength for the first two days. To this liquor add half bag of salt and 15 pounds flour alum, dissolved in boiling water. After 48 hours the liquor may be strengthened to 8 degrees, and kept there until the fifth day. Then haul up and drain. Press for skiving. In case any of the sides are too heavy, split by machine. Put back in tan three days more, strengthening liquor twice daily to not over 10 per cent., adding another half bag of salt and also 15 pounds flour alum.

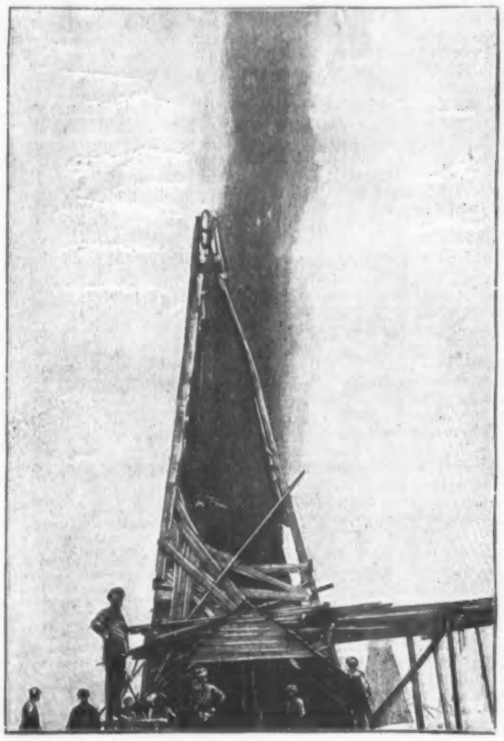
On the ninth day of the tanning, strike out on the flesh side. Scour on grain and oil on grain with cod oil. Dry out in moderately warm room. Then dampen

to stiff. Pack down overnight. Use 200 pounds dry leather to each mill in stuffing.

For stuffing, use 3 gallons curriers' hard grease, 3 gallons American cod oil.

Strike out from mill, on flesh. Set out on grain. Dry slowly. Trim and board, length and cross. The stock is then ready to cut.

The time for soaking the hides may be reduced one-half by putting stock into a rapidly revolving reel pit, with a good inflow of water, so that the dirty water



A NAPHTHA SPRING WHICH HAS DESTROYED THE UPPER PORTION OF A DERRICK FRAME.

washes over and runs off. After ten hours in the soak, put your stock into a drum, and keep it tumbling five hours. You gain time, and get soft stock at once.

In liming, where the saving of the hair is no object, softer leather is obtainable by using 35 pounds sulphide of sodium with 60 pounds lime. Then, when the stock comes from the limes, the hair is dissolved and immediately washes off, and saves the labor of unhairing and caring for the hair, which in some cases does not pay.

THE RUSSIAN PETROLEUM INDUSTRY.

THERE are few natural products that possess such universal and diversified applications as petroleum, and yet comparatively few of the many millions who daily use it, or at least see it, know what petroleum really is, where it occurs and how it is obtained. For this reason we shall give, in what follows, a brief account of the Caucasian petroleum industry, especially with respect to the peninsula of Apsheron, on the Caspian Sea.

This petroleum region is second in size only to the oil fields of Pennsylvania. It is true that large quantities of oil are obtained in Galicia, Roumania, Sumatra, Java, Japan and in many other places, but all of them taken together cannot produce near the quantity of oil obtained from Caucasian and Pennsylvanian fields.

Before we discuss the present state of the industry, it will be of interest to learn how petroleum originated in the creation of the world and how long it has been used by man for his various purposes.

According to the present theory of science, it seems indisputable that petroleum is of animal origin, and, moreover, the product of a transformation in enormous masses of dead marine animals. At first it would seem somewhat improbable to anyone who has a conception of the apparently inexhaustible oil riches concealed in the earth, that such an enormous gathering of marine life could occur in a single spot; still it is possible to become reconciled to this idea when it is remembered that there are in the sea thousands of islands which owe their existence entirely to those exceedingly minute animals corals, and that whole mountain chains are composed of chalk, which likewise consists of the microscopic shells of marine animals.

Nevertheless, some time was required before the theory regarding the animal origin of petroleum found favor and supplanted those early views according to which petroleum originated in the action of water on molten iron. The new theory received strong support from the experiments of Engler, who actually produced petroleum by the distillation of shells and fish oil.

In the course of centuries these gaseous masses were changed into petroleum and covered by a more or less thick stratum, so that we must now bore several hundred meters into the earth in order to procure the treasures there gathered.

Although the birth of the industry hardly extends back more than forty years, petroleum was nevertheless known in the most ancient times, and was even employed for various purposes. In the second book of Maccabees, second chapter, references are made from which we may infer that the Jews on their march to Persia found pits in which the Persian priests concealed the sacrificial fires that broke forth from the earth. Contemporaries of the prophet Nehemiah made a search for these hidden fires, protected them by means of inclosures, which then formed isolated places for sacrifice, and received the name "Nephtar" and also "Nephtoi." These words signify "place of atonement," and from them our modern word "naphtha," with its usual meaning of petroleum, may possibly be derived. Zoroaster, the founder of fire worship, the home of which was the northeastern slope of the Caucasus, certainly received the suggestion for the foundation of this original form of worship entirely from the immense fires which broke through the soil in various parts of the peninsula of Apsheron. These fires were fed by petroleum gases which issued from fissures in the earth and continue to escape even to this day.

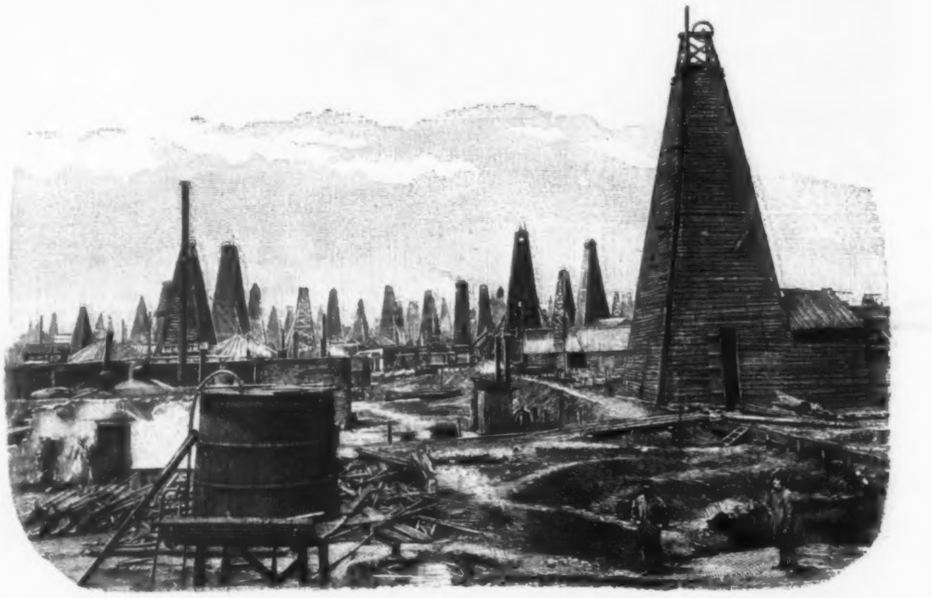
Fire worship in Apsheron was supplanted by the Russian cross and retreated to India, where we still see it continued by the Parsees. The eternal fires, however, remained, but are now used only for a very prosaic purpose, namely, for burning lime. The last memorial of that religion is a Parsee temple in a fairly good state of preservation, situated near the village Surakhani, at a distance of about fifteen kilometers from Baku. In the courtyard of this massive square structure the gases escaped from crevices in the earth and were partly enkindled during the religious ceremonies and partly allowed to enter chimneys, at the openings of which they were also ignited.

Such discharges of gas may be observed in many places on the earth and are particularly violent in America in the vicinity of Pittsburg. In the latter place many stock companies have been formed for the purpose of adapting the gas to industrial and domestic uses. When we consider the fact that in North America some six hundred billion cubic feet of natural gas are annually used, we may obtain an idea of the enormous quantity of the gas contained in the earth.

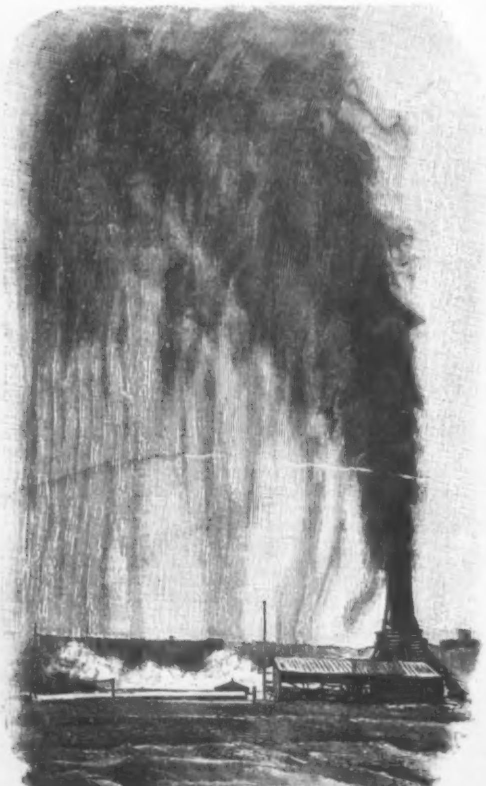
The tourist who arrives at Baku can observe the undoubtedly rare spectacle of seeing the Caspian Sea burning in several places on its surface. The gas which ascends from springs at the bed of the sea may be ignited at the surface, where it burns with a bluish flame until a strong wind extinguishes it.

Let us now turn to the petroleum industry in the peninsula of Baku.

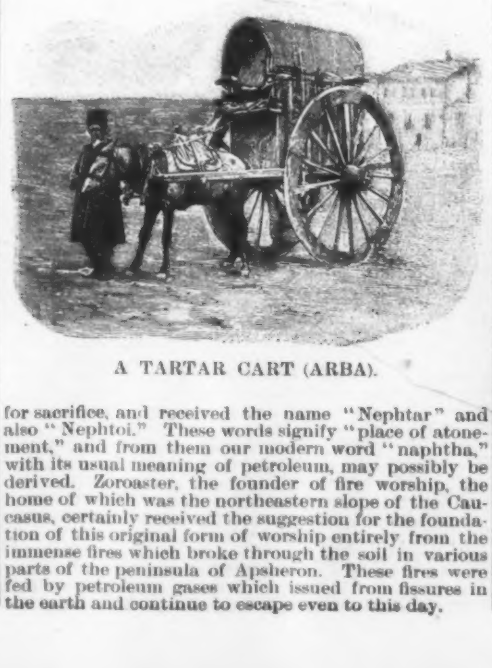
Even before the period in which one can speak of an industry, no small quantities of naphtha were transported on the backs of camels many hundred miles to



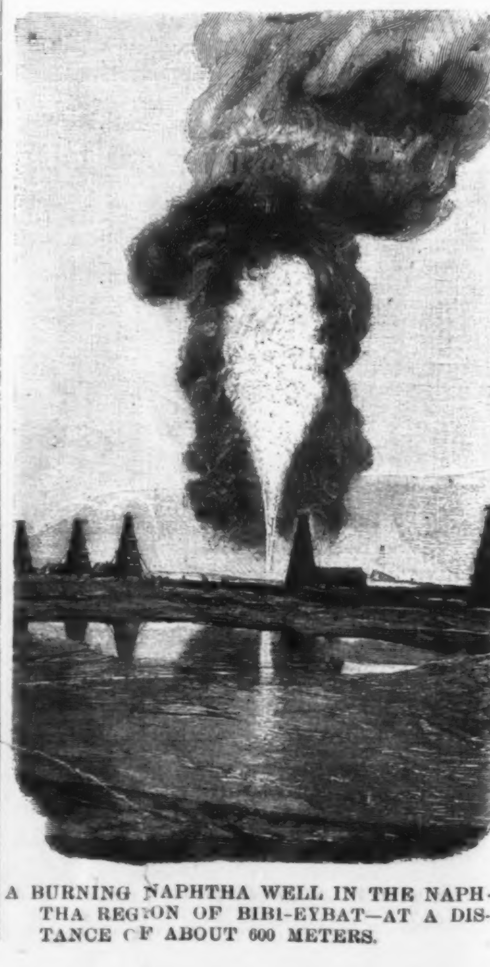
A GROUP OF DERRICKS IN BALAKANI, NEAR BAKU.



A NAPHTHA SPRING.



A TARTAR CART (ARBA).



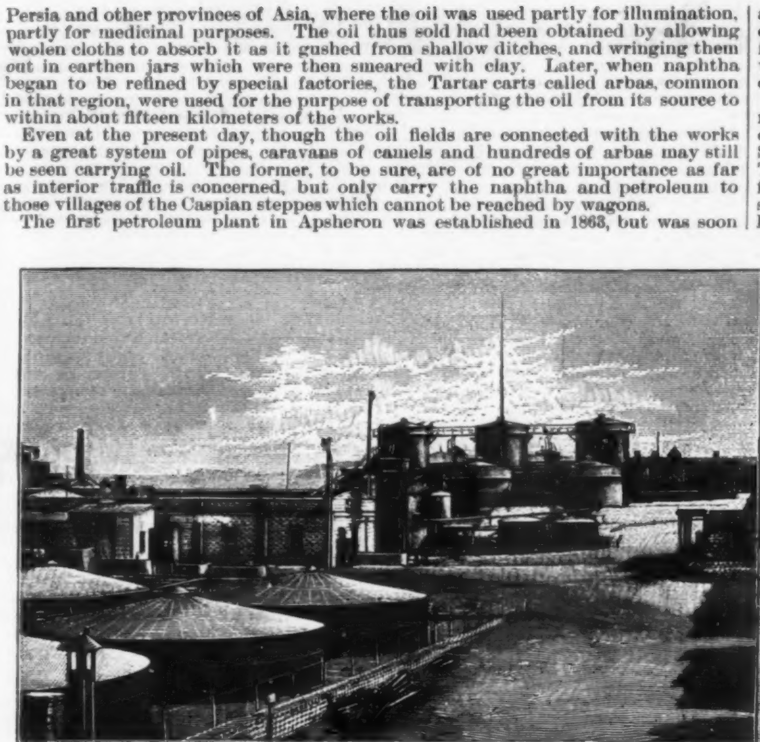
A BURNING NAPHTHA WELL IN THE NAPHTHA REGION OF BIBI-EYBAT—AT A DISTANCE OF ABOUT 600 METERS.

A STREET IN THE BLACK CITY.

Persia and other provinces of Asia, where the oil was used partly for illumination, partly for medicinal purposes. The oil thus sold had been obtained by allowing woolen cloths to absorb it as it gushed from shallow ditches, and wringing them out in earthen jars which were then smeared with clay. Later, when naphtha began to be refined by special factories, the Tartar carts called arbas, common in that region, were used for the purpose of transporting the oil from its source to within about fifteen kilometers of the works.

Even at the present day, though the oil fields are connected with the works by a great system of pipes, caravans of camels and hundreds of arbas may still be seen carrying oil. The former, to be sure, are of no great importance as far as interior traffic is concerned, but only carry the naphtha and petroleum to those villages of the Caspian steppes which cannot be reached by wagons.

The first petroleum plant in Apsheron was established in 1863, but was soon followed by others; and it was not long before there arose near Baku a great factory quarter comprising some two hundred works, which on account of its black walls and chimneys bears the appropriate name of the "Black City."



PLANT FOR THE CHEMICAL PURIFICATION OF PETROLEUM IN NOBEL'S FACTORY.

At first the industry had to struggle against many difficulties, the most prominent of which was probably the lack of all business ability. The manufacture of a serviceable illuminating oil from crude petroleum was, moreover, not yet understood; and as the oil burned with a poor, sooty flame, the public bought it very unwillingly. Ludwig Nobel, brother of the ingenious inventor of dynamite, who died but a short time ago, was the first to develop the Russian petroleum industry to such a degree that its products were enabled to find a place in the markets of the world and to open the doors of palaces and huts alike.

Naphtha in Apsheron is obtained from four principal centers of supply, all within nine to fifteen kilometers of the Black City. From these centers the naphtha is conducted to the works by a system of pipes. The points of supply are Balakani, Surakani and Romani, northeast of Baku, and Bibi-Eybat, southwest of Baku. The last mentioned is the smallest of the four naphtha fields and is situated at the foot of a barren ridge of hills; the other three are situated in the middle of the steppe. The traveler who journeys over the steppe of Apsheron perceives at the horizon a dark mass, which assumes the appearance of a forest of fir trees, over which there hovers a smoky cloud. It is only by journeying still further that he distinguishes the derricks of Balakani standing closely together and constantly at work, raising to the surface the treasures of naphtha which lie at a depth of several hundred meters.

Everything is dripping with brown naphtha. To one unaccustomed thereto it gives off a most penetrating odor, which is, however, no longer noticed by the inhabitants of the Black City.

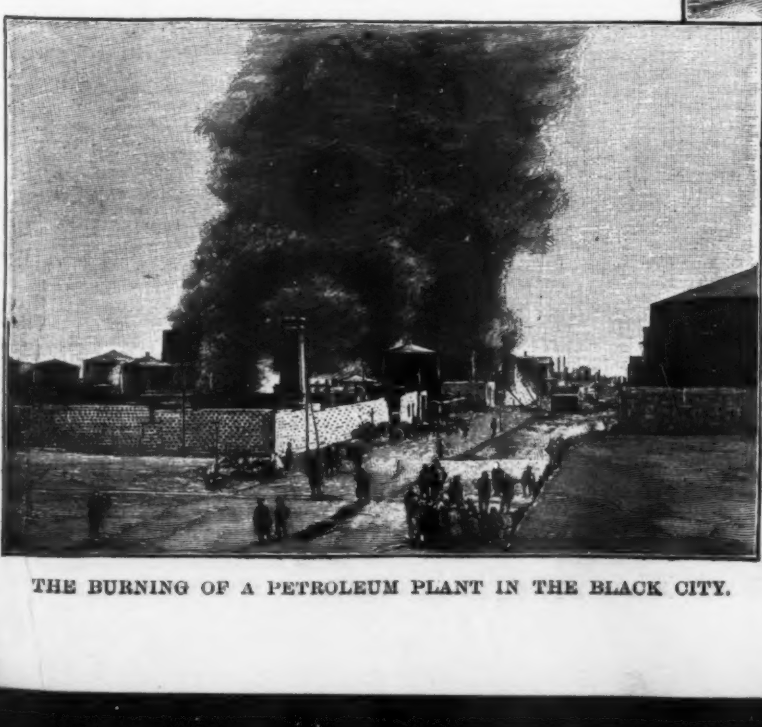
Naphtha must usually be pumped to the surface, but it happens not infrequently that the oil is forced out under such powerful pressure, accompanied by a noise like thunder, that everything in the vicinity is destroyed. Before the eruption of a naphtha spring, great quantities of gas are discharged from the boring, carrying along sand, mud and stones of the size of one's head and hurling them to a height of 100 to 200 meters. The striking of the stones against the wooden framework of the derrick produces a deafening noise, and when at length the brown stream of naphtha bursts forth, the framework can no longer withstand the strain and falls to pieces.

Many wells continue in a state of eruption for several months, while, on the other hand, others only boil up periodically, i. e., disappear at regular intervals in order to burst forth again in a certain period with new force.

PLANT FOR THE DISTILLATION OF PETROLEUM.

Only he who has seen a naphtha well in eruption can form a conception of the grandeur of that spectacle. Many wells force the naphtha to a height of more than a hundred meters and yield in twenty-four hours 100,000 to 150,000 kilogrammes of oil. When such a great spring suddenly bursts forth, the problem of disposing of these vast quantities of liquid is one not easily solved, even though there are in every naphtha region numerous large reservoirs dammed by strong earth walls and having a capacity of many million kilogrammes. The pumps are unable to remove the naphtha collected in the reservoirs as rapidly as it issues from the earth, and the result is an inundation which, as every one can readily understand, is by no means pleasant for the inhabitants of the naphtha region. Moreover, the fortunate proprietor, who by a stroke of good luck has become many times a millionaire, may by such an inundation and the indemnity connected with it become a very ordinary mortal. Gather in while you may the riches which Mother Nature showers upon you, is the rule to be followed in such cases.

That great danger of fire is connected with the eruption of a spring is readily understood; for there are in the naphtha fields not only human dwellings, but also hundreds of furnaces, which, coming into contact with the inflammable naphtha, might produce fatal results. Indeed, there are no



THE BURNING OF A PETROLEUM PLANT IN THE BLACK CITY.

few conflagrations of an extent and grandeur of which nothing is known in other countries.

A few weeks ago oil began to flow in great quantities from one of the Rothschild borings in the naphtha fields of Bibi-Eybat, and it was reckoned that the spring yielded daily 120,000 kilogrammes of oil. Before many hours had elapsed, a fire broke out in a manner not yet accounted for, which burned continuously for ten days and nights. To describe the impression made on an observer by this spectacle would be an impossibility. I drove up to the conflagration, and there, standing before the flaming well, I understood for the first time how Zoroaster could conceive the idea of establishing the worship of fire. The great tongue of flame shot into the sky to a distance of some 200 meters, giving rise to a loud rumbling noise that could be heard fifteen kilometers away. I took several instantaneous photographs of that grand spectacle, but I obtained only two fairly good negatives. The gelatine of the other plates melted, though exposed at a distance of about 200 meters, such was the intensity of the heat even at that distance.

Of course, no one can for a moment think of extinguishing the flames; no human being can endure the heat within more than 100 meters of the spring, and man is therefore compelled to stand idly by, impotent and helpless while the terrible element destroys millions.

After ten days had passed, the eruption fortunately subsided of its own accord, and the fire died a natural death.

Let us leave the naphtha fields and travel on toward the Black City for a distance of twelve kilometers. Here it is that the naphtha is refined by some 200 factories, to be sent from this point to all parts of the world.

Before us is situated a grayish black mass of buildings from which hundreds of chimneys rise, each sending into the air dense volumes of black smoke that hover over the city in a heavy, never-disappearing cloud. The view is cheerless; not a green leaf, not a patch of white wall breaks the gloomy monotony, and if the sucking and pounding of the pumps did not remind us that life was present here, we would be forced to believe that we stood before a ruined city. This impression is strengthened by the appearance of the house tops, which, after oriental fashion, are all flat, not a single structure possessing a roof in our sense of the word.

The appearance within the city is still worse; for there are no streets worthy of the name. Everything is floating in naphtha, and the hundreds of pipes lying on the ground in all directions make the passage-way exceedingly dangerous.

The largest and best equipped plant is that of Nobel Brothers, in which alone as much oil is refined as in all the other works put together.

The Nobels not only manufacture naphtha products, but also all the chemicals and machinery necessary to a naphtha plant. Connected with their petroleum plant, we have therefore a sulphuric acid and soda plant, as well as machinery works in which everything is produced from the simplest pipe to the finest pump.

In Nobel's works about 1,000,000,000 kilogrammes of naphtha are annually refined, from which in round numbers there are obtained 10,000,000 kilogrammes of benzine, 350,000,000 kilogrammes of petroleum, 300,000,000 kilogrammes of lubricating oil and 300,000,000 kilogrammes of "masut."

This last substance is a thick dark oil, an excellent fuel, which remains in the retorts after distillation. All the industrial and domestic furnaces in Baku and vicinity, besides all the furnaces of the locomotives and steamers in southern Russia, are fired exclusively with this residuum.

It possesses a calorific value double that of coal; it is most readily used as a fuel, since its combustion is more complete than that of coal, and the production of smoke consequently minimized; but what is of most importance, no stoker is required, a regulated cock attending to the steady and uniform supply of the fuel.

The process of refining must perform the work of separating the individual constituents from the crude brown naphtha, and by proper chemical purification so to transform them that they can be used for certain purposes. In this way we receive chiefly benzine, petroleum and lubricating oil. Paraffine is not obtained from Caucasian oils, but from those of America, Galicia and Roumania.

The separation of the individual constituents is performed by a process of distillation that takes place in huge wrought iron retorts which, in the large establishments are usually connected in batteries and are continually in action; i. e., the crude oil enters the first retort, where those components having the least specific gravity are given off, is then conveyed into a second retort, where the components having the next smallest specific gravity are distilled over, passing thus through fourteen to sixteen retorts before all the useful portions of the benzine and petroleum have been distilled.

Into the first retort naphtha flows continually, and from the last there emerges a thick black residuum free from all benzine and petroleum. This "masut," or residuum as mentioned above, is either used as a fuel or is passed into a second battery of retorts, whereby the various lubricating oils are obtained.

The distillates in this state by no means answer the purpose for which they are intended; for mingled with them are substances received from the crude oil during distillation, which render the distillates impure. In order to remove these impurities, concentrated sulphuric acid must be mixed with the distillates. The acid dissolves the impurities and assumes a dark color. It is then poured off and the acidified oil is further purified by treating it with a solution of soda. The mixing is performed by a current of air which violently agitates the whole liquid.

In the works of Nobel Brothers, three sheet iron vessels having a capacity of twelve carloads are used for the purification of petroleum. These vessels are placed at some distance from the ground, and the acidified petroleum is poured from them into receptacles standing somewhat lower than the first; here the oil is mixed with soda lye, passing, after the removal of the latter, into reservoirs standing lower than either of the other two sets. Here it is allowed to settle and clear.

Part of the purified naphtha products are transported by rail to Batum, on the Black Sea, whence they are sent to every portion of the globe; and part carried by ships to Astrakhan, thence to be transported by smaller vessels up the Volga into the interior of Russia.

For shipment by rail, so-called tank cars, having a capacity of 100 to 150 cubic meters, are exclusively employed. The ships, on the other hand, are provided with cisterns, six or seven in number, occupying the entire hold, which may, therefore, be completely filled with petroleum.

Gas and electricity have been unable to crush the petroleum industry. On the contrary, the supply of oil illuminants is annually increasing. From the residuum of distillation valuable dyes may be obtained; but just at present their manufacture is unprofitable, owing to the low price of coal tar. A hundred years hence, who knows what may be done with petroleum?

We are indebted to the Illustrirte Welt for the cuts and particulars.

THE PREVENTION OF NERVOUS DISORDERS —PRE-NATAL INFLUENCES.

By Alexander L. Hodgdon, M.D., of Baltimore, in Health Magazine.

The homely but well known saying, that "an ounce of prevention is worth a pound of cure," is most thoroughly exemplified in the attempt to prevent the various forms of insanity and diseases of the nervous system, and where can we better direct our attention primarily than to those who are to perpetuate the coming race and to people this earthly sphere?

It is highly probable that primitive man departed this life through the gradual failure of all the forces concerned in the promotion of vitality, and that a comparatively painless death at an advanced age was the result of the gradual extinction of the spark of life; but the human family in this generation have so far retrograded that many diseases have fallen to their lot which were probably unknown in the days of the original progenitors of the species. Conditions at that time were somewhat different from what they are at present. Man lived almost wholly an outdoor life, he inhaled more oxygen and was far removed from the cares and vexations which harass many in the everyday life found in civilized communities, where almost numberless individuals fight penury and want, eke out a comfortable livelihood or strive toward the amassing of great riches over the desks of the counting house and in our immense bazars. The vast majority of this large army, who have spent the brightest hours of the day imprisoned within four walls, which act as barriers to the ingress of oxygen and sunlight (red blood products and nerve vitalizers) and egress of carbon and other impurities given off by the lungs, go home—very likely ride home—and do not take any systematic exercise whatever in the open air.

In bicycling and other forms of outdoor exercise the increased lung action causes an extra quantity of life-giving oxygen to be conveyed to all nerve filaments, even to the remotest portions of the body, and on a clear, frosty day, when the air is fairly laden with ozone, those who tramp with gun in hand across the field, ever on the alert for the whirr of the quail or scurry of the hare, or on a bicycle, pedaling or coasting rapidly down some steep incline, with handle bars in viselike grip, must consider it indeed an inestimable pleasure to live and be an integral portion of this great creation.

Sufficient outdoor exercise is to be recommended to those who contemplate becoming fathers or mothers, and who desire to have children come into the world with minimum proclivities toward affections of the nervous system, insanity and other diseases, such as consumption and scrofula. The matter of excesses in parents may entail upon their offspring some obstinate nervous affection. Nature tends to rectify the mistakes of any of her misguided children, and all know there is no such thing as spontaneous generation. Hygienic agencies tend to aid Nature in this her great work.

The life-giving principle is conveyed from father to son and from mother to daughter, save in the primal creation, when life was given to all things through the agency of a Supreme Being. So any taint which may have crept into the blood is constantly, through this cause, being worked upon by its mysterious agencies, with a tendency to elimination and a reversal toward the normal standard of health.

We can see from this that the choosing of a wife or husband, when such a one is wisely selected, is an aid to the strengthening of the human race. The young will love, the old may, but it would be well if those desiring to marry, and possessing strongly neurotic tendencies, were only thrown in the company of persons of the opposite sex possessed of stable nervous systems, as then the elimination of nervous diseases, to a great extent, in the coming generation would in a large part be assured. But it would seem to be the irony of fate that those of neurotic constitutions seem to be especially attracted to those of the opposite sex possessing the same attributes. The marriage of cousins per se has, I believe, nothing to do with the determination of nervous diseases in the offspring, unless a marked hereditary predisposition existed in the family, and then the same rule would work in the children of husband and wife between whom no consanguinity exists, provided a taint should be present in the families of both; on the contrary, it is unquestionable, in cases where you can be reasonably sure of no marked nervous inheritance, that the children of consanguineous marriages may develop a mentality far above the majority of those who are the product of non-consanguineous marriages.

Furthermore, we cannot allow the subject to drop without alluding to the condition known as atavism, the inheritance of acquired peculiarities, and maternal impressions. By atavism we mean a feature or taint which may have been present in a member of one generation, which may have lain dormant in individuals of the succeeding generation and have become apparent in one or more members of the third generation. Such a condition of affairs in the vegetable kingdom is known as sporting, and is well exemplified in members of the squash family, where apparently the seed from one variety may have been planted and yet the product appear totally dissimilar to that of the parent. Such variations from a given type are taken advantage of by propagating entirely from the new variety, and in this way producing a seedling which will have all the characteristics of the one which deviated, and produce a new variety of plant. Now this is only done when it is thought that it will produce an improved plant, otherwise, should the cultivator desire to preserve the former strain, he will cross it with some plant of a better quality and thus render it better; and what applies to plants in this respect is equally true in regard to the human family.

The mother who carries and nurtures the unborn babe within herself has the responsibility of future generations resting upon her shoulders. The existence of maternal impressions has been scouted at by many, but that they do exist there is hardly the shadow of a doubt, as proofs which would show conclusively to the most confirmed questioner are constantly appearing. If possible during this delicate period the prospective mother should be tenderly sheltered from all hideous and unpalatable sights, so that there may be no transmission to the unborn babe of a shattered nervous system.

MENES NO LONGER A MYTH—HIS TOMB FOUND.

The founder of the long line of kings who ruled over Egypt for some thousands of years was Menes—at least, so we have been taught to believe. With him begins the story of civilization in the Nile Valley, but whether Menes was a real person has been doubted, even more perhaps than the reality of Romulus—the founder of that other imperial land to which Egypt was destined to become subject. But now the actual tomb of Menes is reported to have been found. Thus another great fact in the history of the earliest civilization stands forth to build upon. Commenting on the discovery, The Chronicle, of London, prints the following:

"A very interesting discovery has been made by Dr. Borchardt of the Gizeh Museum, which adds immensely to our knowledge of early Egyptian history, provided it is fully sustained. The scholars have hitherto told us that the origins of Egyptian history were wrapped in absolute obscurity, and in particular that the founder of the first Egyptian dynasty, whose name was Menes, was a mythical person, like Cadmus of Thebes and old Anchises, and many other worthies who, in simpler times, were regarded as real men. To Menes was ascribed by the ancient Egyptians the canals of Egypt and the union of Upper and Lower Egypt into one kingdom.

"Last year a tomb was discovered near Thebes, and now Dr. Borchardt has identified that tomb with that of Menes, who turns out to have been a real character. The bones and the seal of Menes, whose body was burned, not embalmed, and the inscription in which he calls himself the King of Upper and Lower Egypt, have been so clearly identified that it would appear there is little ground for doubt. At least the authority of M. de Morgan and Dr. Borchardt cannot lightly be set aside, and they are agreed as to this tomb being that of the real founder of the first Egyptian dynasty. In other words, Menes was no myth, but a real human being, the founder of a kingdom which endured, under the guidance of a great and powerful priesthood, for thousands of years.

"It is clear that there is far more in ancient tradition than the skepticism of modern historians, especially of the German school, has been wont to admit. Much of the old Roman tradition, set aside by Niebuhr, has now been vindicated beyond all dispute by the actual evidence of brick and stone. The Biblical records, which some of the critics tried to dissolve away into thin air, have been justified by tangible evidence. One school of critics resolved Abraham into a sun myth, but the personality of the mighty founder of the most tenacious race in human history stands out again in its imposing outlines. The German advanced criticism of the New Testament has been pretty severely handled by the still newer critics with the latest learning. The methods of Strauss no longer hold in the minds of serious thinkers.

"It seems not unlikely that much of ancient history will be reconstructed, not as the subjective critics who evolved camels out of their moral consciousness imagined, but by a very substantial incorporation of much that was held to be legendary or mythical into the surer history of the future. The new history calls archæology, craniology, and inscriptions to its aid, and so earns for itself a position of strength which before our century was unknown. The strange paradox is brought about that the further we are removed from ancient times, the more we know about them. In a special degree it may be said that a fairly complete reconstruction of Egyptian history and religion would be a most important contribution to the knowledge of the history of mankind, and this knowledge seems to be on the point of being obtained.

"According to M. de Morgan, real Egyptian history begins with a race of conquerors whose origin was probably in Babylonia. They brought with their wheat and barley, the ox, the sheep, the goat, the beginnings of writing, and perhaps the use of tools. They blended with the primitive race, living in the stone age, and from that union the historic Egyptians proceeded. It was this mixed race which built the pyramids and temples. So far, if M. de Morgan is to be relied on, and there are few more trustworthy investigators, have the researches into the history of old Egypt led us, and it is a long way."

A new device for getting rid of snow has been tried by the Boston & Maine, for use at the Union station in Boston and in the yards adjoining, says The American Engineer and Car Builder. The car rests upon four ordinary wheels, but sits very low. It looks like a long box open at the top and with vent holes in the bottom. Through the center of the interior runs a long pipe with diverging arms, and at frequent intervals through its entire length and that of the arms are small holes. When this car is attached to a shifting locomotive the pipe is connected by means of a flexible hose with a live steam coil in the engine. The snow is shoveled into the box and quickly melted, the water running out through the vent holes and down between the ties of the bridge into the river. It is calculated that this car can care for snow faster than 25 men can shovel it.

ENGINEERING NOTES.

The town of Ostend, Belgium, is making expensive improvements in its harbor, so as to make it accessible to steamers of the greatest draught in existence. The total cost will be about $3,000,000, of which the town will defray a little over one-third, the balance being paid by the Belgian government.—Uhland's Wochenschrift.

Whether to reverse a locomotive equipped with driving brakes or to rely upon the brakes alone in making quick stops has been the subject of a number of communications recently printed in The Railroad Gazette. The discussion points very decidedly toward the use of driver brakes alone, without reversing, as the proper method of making the quickest possible stop.

In the mercantile marine, it is beyond question, says The Engineer, that pressures are rising. The limit has been for the time attained by the "Inchmona," whose five-cylinder engines work with 250 pounds of steam. A good deal of criticism has been expended on Mr. Mudd's engines, but they have accomplished all that he promised, at all events that is the opinion of the owners, who have recently handed over to the directors of the Central Engine Works, West Hartlepool, the large balance which was held over conditionally until a year's working had proved that the engines would satisfy the guarantee. The owners have paid on the basis of a consumption of only 1·15 pounds of coal per horse power per hour—an economy which has not, we believe, ever before been attained at sea over twelve months.

At a recent meeting of the French Academy of Sciences, Col. Bassot read an interesting paper tending to establish the fact that the great French tower has a daily movement of considerable magnitude. He explained that the expansion of the metallic components of the structure produces a torsion movement from sunrise to sunset which traverses a curve of 10 centimeters. This movement is repeated in an inverse direction during the night, as the column becomes cooled, so that the lightning rod on the summit of the tower is in constant motion. Col. Laussedat, director of the Conservatoire des Arts et Métiers, confirms Col. Bassot's statements. He says the tower simply obeys the physical law of temperature influence. In summer the expansion is greater than that in winter, and the movement reverses at night, owing to contraction due to the cooling down of the mass. Yet this torsion will in no case compromise the solidity of the structure, which is absolute. The constructors had, at the time of erection, all this in view, and calculated for it, so that while the matter is one of interest, it is neither startling nor, from a mathematical standpoint, of serious importance.

In the mining district of Dortmund, in Rhenish Prussia, statistics on the accidents to ropes have been collected since 1872. The statistics are not official, and not complete—that is to say, they do not comprise all the haulage ropes used in the district—but they offer a certain interest. In addition to 105 aloe or hemp ropes, there were in use 736 steel and 147 iron ribbon cables and 3,536 steel and 881 iron round wire cables. The application of iron ribbons ceased after 1881. The percentage of accidents—i. e., cases of sudden breakages—in the 25 years, 1872 to 1896, averaged 4·66, the iron cables of both classes proving much inferior (the percentages are 12·9 and 11·9) to the steel ropes. A very satisfactory feature of these statistics is that the percentage—the 4·66 is the total average—has steadily decreased; it began with 19·3 per cent. in 1872 and has never come up to 2 since 1891. The round wire ropes have lasted two and three times as long as ribbons. Two of the wire ropes had done over 5,000,000,000 of foot pounds. These results agree entirely with the experience gained in the Silesian mines. These statistics are reproduced in the Oesterreichische Zeitschrift für Berg und Hüttenwesen. We take this opportunity of drawing attention to an excellent paper by General von Lauer on the "Action of Various Explosives in Firedamp Mines."

A report of the commanding officer of the Watertown Arsenal, says The Engineer, recently issued, contains the record of a series of tests of bolted and riveted joints upon a number of samples submitted by the Berlin Iron Bridge Company. The series comprises tests of riveted and bolted joints, otherwise similar, with 2, 3, 4, and 12 rivets in one sample and bolts in the other sample otherwise similar, in single longitudinal row and single shear; 2, 3 and 4 in single row and double shear; two rows of 3, 4 and 5 bolts and rivets each in single and the same combinations in double shear, some of the combinations being repeated with different widths and pitches. There is also an angle iron joint with two rows of three each, bolts in one case and rivets in the other, in single shear. The specimens were designed to fail by the shearing of the bolts and rivets, and this is generally the case, the exceptional tests in which the plate failed being repeated to produce shearing of the rivets or bolts. Taking fifteen tests in which the failure was by the shearing of both bolts and rivets, we find for the riveted joints an ultimate average tensile value of 34,103 pounds per square inch of gross section and for the bolted joints 25,598, the bolted joint averaging thus almost exactly 75 per cent. of the value of the riveted joint. A joint consisting of two rows of five rivets each failed at 35,940 pounds by fracturing the plate across the first row of rivet holes, the tension per square inch of net plate section being 42,890. A similar joint bolted failed at 19,000 by shearing the bolts. In every case where the riveted joints failed in the plate the similar bolted joint failed by shearing the bolts at a much lower tension. The most important and interesting feature of the test, however, says Power, is the elongation, which is much greater in the bolted joints. A joint of four rivets in single row and single shear stretched 0·0012 inch, 0·0034 inch and 0·0074 inch under strains respectively of 10,000 pounds, 20,000 pounds and 30,000 pounds. The corresponding bolted joint stretched 0·0060 inch under 10,000 pounds, 0·1261, over ⅛ inch, under 20,000 pounds, and failed by shearing the bolts at 22,000 pounds. This is representative of the comparative action of all the joints. Punched holes with dies ⅞ and ⅝ and punches $\frac{13}{16}$ and $\frac{11}{16}$ were used with ¾ and ⅝ iron rivets and bolts.

MISCELLANEOUS NOTES.

It is understood that work on the buildings and grounds of the Paris Exposition of 1900 is well under way and about 3,000 men are regularly employed.

An ingenious stage waterfall devised by M. Gailhard has attracted attention at the Paris Opera balls. It is made of tulle stretched on frames imitating the curves of a fall. Behind it little streams of water are discharged through perforated pipes against a metal plate, so as to throw a spray upon the tulle. When the electric light is played on this, the effect is magical.

A tunnel 60 feet below the level of the streets of Edinburgh, constructed for the use of the North British Railway, some fifty years ago, has been used for the past ten years as a place for the cultivation of mushrooms. It furnishes a constant temperature and an absence of light, both of which conditions are favorable for the growth of the mushrooms; and so successful has the propagation been that the Scottish Mushroom Company is said to be in control of the British market for cultivated mushrooms. It uses 800 mushroom beds, 12 by 3 feet, and the output at times amounts to 5,000 pounds of mushrooms per month. The effect has been to diminish the amount furnished by the French growers, who formerly controlled the English market, to less than a per cent. of the total consumption.

The Chamber of Deputies of the Grand Duchy of Luxemburg has just voted the budget for 1898, which makes the receipts 11,300,000 f. and expenses to the amount of 9,800,000 f. The little duchy owes its financial prosperity to participation in the German revenues, certain parts of which were allotted to it by treaty, under conditions that have now become obsolete. Luxemburg had a population in 1895 of 217,583, of which 109,282 were males and 108,301 females. The budgets of the last four years have been as remarkable as that of 1898. In 1893 the receipts exceeded the expenses by 1,572,314 f.; in 1894 by 1,628,188 f.; in 1895 by 1,841,526 f.; and in 1897 by 1,145,550 f. In 1859 the public debt amounted to 3,500,000 f., and bore interest at 5 per cent. Now it is 12,000,000 f., and bears interest at 3½ per cent. The army is composed of 150 men, three horses and a band of music. The same story of financial prosperity and frugality may be told of the Democracy of Andora, the Principality of Monaco, and the Republic of St. Marin. Andora, in order to maintain its independence, is supposed to pay 960 f. to France and a tribute of 460 f. to the Bishop of Urgel.

The value of all classes of farm animals in the United States January 1, 1898, was $150,000,000 greater than a year ago, according to the annual live stock report just published by The American Agriculturist. This places the total value at $2,037,000,000 against $1,887,000,000 a year earlier. In this improvement every class of farm animals except mules bears a part. The most gratifying feature of the showing this year, because it must be taken as indicative of the permanent character of the improvement, is the fact that this gain in price is quite generally accompanied by an increase in numbers. Horses and mules show a slight decrease, though in case of each the general situation is improving, and horses show an advance of approximately $2.31 per head. The number of milch cows has increased slightly, and the average price advanced $3 per head. The total number of sheep is now estimated at more than 1,000,000 above last year's figures, and the average price is placed at $2.50 per head, against $1.95 in 1897 and $1.60 in 1896. The highest average price of sheep per head since 1890 was reported January 1, 1893, at $2.66. It is estimated there are 2,000,000 hogs more in the country than a year ago, and the price, though low, has shown a slight gain, indicative of the strength of the general situation.

This country in 1897 exported 39,532 horses and 7,473 mules, the total value of which was $5,314,000, making a rather important item of foreign trade, says The Kansas City Star. The exports of horses have increased over five-fold since 1893. There were never as many as 5,000 sent abroad prior to that year. The increase is due to the decline in the value of horses in this country resulting from their displacement by cables and electricity on street car lines, and the general depression in the country. There is, undoubtedly, a surplus of horses in the United States and probably this will continue, so that exports are likely to go on increasing. The agricultural department is doing all it can to open foreign markets for American horses. There is no doubt that horses can be raised in this country as cheaply as anywhere else in the world, and every country which needs to import horses ought to get its chief supply from the United States. The average farm value of horses is barely half what it was five years ago. It is rather strange that prices of horses have not advanced in the past six months, especially in Kansas, where there certainly is a greater demand for them, and less disposition among farmers to sell them. The increased profits of farming ought to have the effect of greatly reducing the number of horses for sale.

A writer in the January number of Chambers's Journal throws some interesting light on rare and peculiar drugs. Saffron, he points out, would strike an ordinary observer as decidedly expensive at $10 a pound, until told that it is composed of the central small portions only of the flowers of a crocus, 70,000 of which it takes to make a pound. Attar of roses sells at $112 odd per pound, and it takes 10,000 pounds—or nearly five tons—of roses to obtain one pound of the oil. Aconitine, extracted from the root of monkshood, is said to be the very strongest poison extant, the dose being 1-600th of a grain. It is sold at the rate of $108 per ounce. Turning from the vegetable to the animal world in search of rare drugs, the writer refers to the musk of the Asiatic deer, which, at $24 to $30 an ounce, must be a prize to the wily hunter. In some of the tropical seas, a floating, sweet smelling mass of ambergris is met with, worth at present $30 per ounce, or $480 per pound in the market. This ambergris is said to be the diseased biliary product of the whale. Another peculiar animal product in use as a drug is a solution of the pure venom of the rattlesnake, given occasionally in malignant scarlet fever; while less strong, if, perhaps, hardly less repulsive, is powdered cockroach, which, in six-grain doses, has been prescribed, with good effect, it is said, for dropsy.

SELECTED FORMULÆ.

To Remove Tattoo Marks.—Make a mass, the consistency of dough, with salicylic acid and glycerin; apply to the tattoo marks and confine with a compress and strips of adhesive plaster for one week. Then remove the layer of epidermis over the marks and apply salicylic acid and glycerin as before. It may be necessary to repeat three times, but usually the second application removes the marks.—Medical Brief.

Bottled Frost.—In dressing the mirror, first clean it and have it perfectly dry. A very pretty and pleasing effect is obtained by the use of a liquid called "bottled frost." This, when applied to a mirror and left to dry, will form in many shapes, all radiating from a focus, this focus forming anywhere on the glass, and when all dry tends to form a most pleasing object to the eye. This frost can be made in the following manner:

Sour ale. . . . . .4 ounces.
Magnesium sulphate . . . . .1 "

Put on the mirror with a small, clean sponge and let dry. It is now ready for the artist, and he may choose his own colors and subject.—The Spatula.

Cement for Amber.—Smear with boiled linseed oil, press strongly together and heat over a clear charcoal fire. To keep the parts in firm contact, it may be well to bind them together with fine, soft iron wire. The surfaces should be carefully cleansed before applying the cement, and as the solvent is very volatile, arrangements should be made beforehand for applying compression so that no time be lost. Also a solution of hard copal in ether has been suggested as a cement. Still another suggestion is that the surfaces be moistened with solution of potassa and then firmly pressed and held together.—Workshop Receipts.

To Clean Paintings.—To clean an oil painting, take it out of its frame, lay a piece of cloth moistened with rain water on it, and leave it for awhile to take up the dirt from the picture. Several applications may be required to secure a perfect result. Then wipe the picture very gently with a tuft of cotton wool damped with absolutely pure linseed oil. Gold frame may be cleaned with a freshly cut onion; it should be wiped with a soft sponge wetted with rain water a few hours after the application of the onion, and must finally be wiped with a soft rag.—Der Stein der Weisen.

To Turn Blue Prints Brown.—The following is said to be a practical manner of turning blue prints to a rich brown color: A piece of caustic soda about the size of a bean is dissolved in 5 ounces of water and the blue print immersed in it, on which it will take on an orange-yellow color. When the blue has entirely left the print it should be washed thoroughly and immersed in a bath composed of 8 ounces of water in which has been dissolved a heaping teaspoonful of tannic acid. The prints in this bath will assume a brown color that may be carried to almost any tone, after which they must again be thoroughly washed and allowed to dry.—Anthony's Bulletin.

Fine Papier Maché.—The following are the ingredients necessary to make a lump of papier maché a little larger than an ordinary baseball and weighing 17 ounces.

Wet paper pulp { dry paper, 1 oz. / water, 3 " } 4 oz. (avoirdupois).
Dry plaster Paris. . . . . 8 " "
Hot glue . . . . ½ gill, or 4½ tablespoonfuls

While the paper pulp is being prepared, melt some best Irish glue in the glue pot and make it of the same thickness and general consistency as that used by cabinet makers. Measure the different ingredients to be used, until the result teaches you what good papier maché is like, and after that you can be guided by your judgment as you proceed. On taking the paper pulp from the water, give it a gentle squeeze, but by no means squeeze it as dry as you can. Now put it in a bowl, put over it about three tablespoonfuls of your hot glue, and stir the mass up into a soft and very sticky paste. Next add your plaster Paris and mix it thoroughly. By the time you have used about three ounces of the plaster, the mass is so dry and thick you can hardly work it. Now add the remainder of your glue, work it up again until it becomes sticky once more, then add the remainder of your plaster. Squeeze it vigorously through your fingers to thoroughly mix the mass, and work it until it is free from lumps, is finely kneaded and is sticky enough to stick fast to the surface of a planed board when you rub a bit on it by firm pressure of the finger. If it is too dry to stick fast, add a few drops of either glue or water, it makes little difference which, and work it up again. When the paper pulp is poor and the maché is inclined to be lumpy, lay the mass upon a smooth board, take a hammer and pound it hard to grind it up fine.

If the papier maché is not sticky enough to stick fast to whatever a bit of it is rubbed upon, it is a failure, and requires more glue. In using it the mass should be kept in a lump and used as soon as possible after it is made. Keep the surface of the lump moist by means of a wet cloth laid over it, for if you do not, the surface will dry rapidly. If you wish to keep it overnight, or longer, wrap it up in several thicknesses of wet cotton cloth and put it under an inverted bowl. If it should by accident or delay become a trifle too stiff to work well, add a few drops of water to the mass, pound it with the hammer and work it over again. If you wish to keep a lump for a week, to use daily, add a few drops of glycerine when you make it, so that it will dry more slowly.

The papier maché made when the above formula was prepared had the following qualities: When tested by rubbing between the thumb and finger, it was sticky and covered the thumb with a thin coating. (Had it left the thumb clean, it would have been because it contained too much water.) When rubbed upon a pane of glass it stuck tightly and dried hard in three hours without cracking, and could only be removed with a knife. When spread in a layer, as thin as writing paper, it dried in half an hour. A mass actually used dried hard enough to coat with wax in eighteen hours, and, without cracking, became as hard as wood; yet a similar quantity wrapped in a wet cloth and placed under an inverted bowl kept soft and fit for use for an entire week.

Such are the qualities of first-class papier maché and the manner of producing them all.

TESTS OF THE SYNCHRONOGRAPH ON THE TELEGRAPH LINES OF THE BRITISH GOVERNMENT.*

THE WHEATSTONE RECEIVER OPERATED BY THE ALTERNATING CURRENT IN TRANSMITTING INTELLIGENCE.

IN April, 1897, a paper† was read before the American Institute of Electrical Engineers, describing the general principles of the synchronograph and the experiments at that time completed in developing it. As stated therein, the next step desirable was to test the system upon long telegraph lines having considerable distributed capacity, the length of the only line used up to that time being thirteen miles. Since then opportunity has been presented to make these trials on actual lines of considerable lengths and having different distributed capacities. Through the courtesy of Mr. W. H. Preece, engineer in chief of the British postal system, every facility has been afforded for conducting the experiments on the telegraph lines of the British government.

The tests were made over loops of varying lengths from the General Post Office, London, where both transmitters and receivers were located. The lines can best be used for experimental purposes on Sundays, and the tests were made on two dates, viz., August 8th and 22d, 1897, when the lines were available throughout the day. Mr. A. Eden, of the technical staff of the engineer in chief, assisted throughout these experiments, and his experience and assistance in conducting the trials were invaluable.

The apparatus available for experiment was more extensive than would usually be found in a laboratory. There was a high frequency alternator of wide range giving practically harmonic waves, from 50 to 720 complete waves per second, actual telegraph lines with values‡ of KR varying from 0 to 261,000, and resistance varying from 0 to 10,000 ohms; an artificial submarine cable representing to within 1 per cent. of accuracy, an actual cable of 180 knots in length, and also the latest types of Wheatstone transmitters and receivers, with adjustable condensers, etc.

The longest loop tried was 1,097 miles, from London to Glasgow, Aberdeen, Edinburgh, and return to London by a different pole line, as indicated on the map, Fig. 4. This contained some iron wire and also 48 miles of underground cable, and a total value of KR equal to 261,000.

It was found in the course of trials with the different apparatus that it was possible to operate the Wheatstone receiver without alteration by means of the synchronograph, and a test was made over the longest line to compare the efficiency of the two transmitters when operating the same receiver under identical conditions of line. The surprising result was discovered that the synchronograph could operate the Wheatstone receiver approximately three times as fast as the Wheatstone transmitter on any line, provided the mechanical limit of the receiver is not already reached. The Wheatstone system operated from London to Aberdeen ordinarily employs two automatic repeaters to increase the speed. Without any repeaters the synchronograph operated the Wheatstone receiver over this line practically up to its mechanical limit. By the synchronograph method of transmission it thus becomes possible to operate Wheatstone receivers at the present speeds without repeaters anywhere in the British Islands.

One of the most important results of the trials to be described has been to emphasize the probability that the sine wave possesses superiority over other forms of wave for any speed, slow or fast.

* Paper by Albert Cushing Crehore, Ph.D., Assistant Professor of Physics, Dartmouth College, and George Owen Squier, Ph.D., First Lieutenant of Artillery, U. S. Army, Instructor Department of Electricity and Mines, U. S. Artillery School. Read before the January meeting of the Franklin Institute, and published in the Journal of the Institute.

† The Synchronograph: a new method of rapidly transmitting intelligence by the alternating current. Published in SUPPLEMENT, Nos. 1114 and 1115.

‡ The value of R is in ohms; K is in microfarads.

To make the experiments more clearly understood, a brief description of the Wheatstone instruments is given.

THE WHEATSTONE INSTRUMENTS.

For a detailed description of the latest types of Wheatstone automatic transmitters and receivers reference* is made to books on the subject, as it is desired to direct attention in this paper only to such essential features as should be noted when a comparative test is made of the Wheatstone instruments and the synchronograph. The diagram, Fig. 1, indicates the arrangement of the parts of the transmitter. The messages are prepared by perforating paper tape with two rows of holes at the proper intervals to secure correct signals, one row on each side. The tape is about 12 mm. wide, and in the center, between the two rows of holes mentioned, runs an uninterrupted series of smaller holes about 1 mm. in diameter, which serve to feed the tape regularly through the transmitter. The large holes in the outer rows always come opposite a central hole. In the figure, W is a star wheel which engages the central line of small holes to feed the paper, and is rotated by a weight actuating clockwork. Geared to the star wheel is the rocker arm, R, which therefore runs in synchronism with the wheel, so that the tape is advanced a fixed distance for every complete oscillation of the rocker. It advances from one central hole to the next for one complete oscillation of the rocker.

* American Telegraphy, by W. Maver, Jr., published by Maver & Company, New York, page 296.

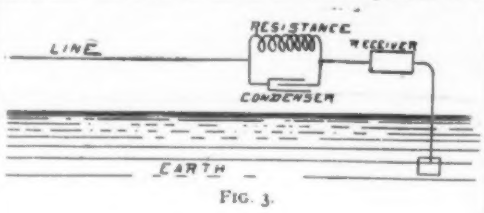


FIG. 3.

FIG. 4.—MAP SHOWING ROUTES OF LINES USED ON AUGUST 8 AND 22, 1897.

A characteristic of the transmitter is the fact that the contact for the electrical circuits is not made through the holes in the paper as in some transmitters; but by the small steel rods, LL', which pass through the holes in the paper, contacts are made and broken in another part of the apparatus by means of the levers, AA', and rods, HH'. For every complete oscillation of each rod, L or L', including an up and down motion, the battery connections are twice reversed, and as the rods move in synchronism with the paper tape, the distance between consecutive holes in the tape when continuous rows are perforated corresponds to two reversals or to one complete wave of electromotive force. The wave of electromotive force impressed upon the line by the Wheatstone transmitter is approximately represented by the broken line shown in Fig. 2, where the letters a and b are shown. Only the positive currents cause the receiver to make a mark. A dot together with the accompanying space corresponds to a complete wave of current. A dash with its following space occupies twice the time of a dot with its space, and corresponds to the time of two complete waves, although in reality it is a single wave with the positive portion three times as long as the negative, and thus the mark for a dash is about equal to three dots.

The chief characteristics to be noted are that the waves of impressed electromotive force are square topped and those for a dash are longer than for a dot.

The Wheatstone Receiver.—An essential part of the receiver is a polarized relay consisting of a permanent magnet and an electromagnet. The armature, to which the recording wheel is attached, is by this arrangement moved in one direction for a direct current and in the opposite direction for a reversed current. The small recording wheel is kept moistened with ink, and every positive current drives it against the paper, while a negative one raises it from the paper. The paper tape is driven forward by clockwork, the speed of which is controlled by an ingenious device, and thus a series of marks is made upon the tape corresponding to the positive portions of any set of current waves. For a wave like that in Fig. 2 there would be dots and dashes received forming the letters a and b. By this receiver only one mark is made upon the paper during a complete wave of current consisting of a positive and negative portion. The reverse currents are not used for making marks on the paper.

The electromagnet of the receiver consists of two solid soft iron cores wound with spools of wire on the differential plan. To give the two coils exactly opposite magnetic effects for duplex working, the two wires are wound together as one upon the spools. The resistance of each coil is made equal to 100 ohms in the British service. They may be connected in different ways when not used for duplex working, with the coils in series making 200 ohms, or in parallel making 50 ohms for the instrument.

In practice it is found that, when connected directly to the line and the return, and operated by the transmitter, the speed obtainable over most lines can be increased by the use of condensers properly arranged. The arrangement of condensers and resistance in actual use in England is indicated by Fig. 3. Common values of the resistance and capacity are about 8,000 ohms and 10 to 20 microfarads, which would vary according to the line.

DESCRIPTION OF THE EXPERIMENTS.

The apparatus was mounted in the experimental

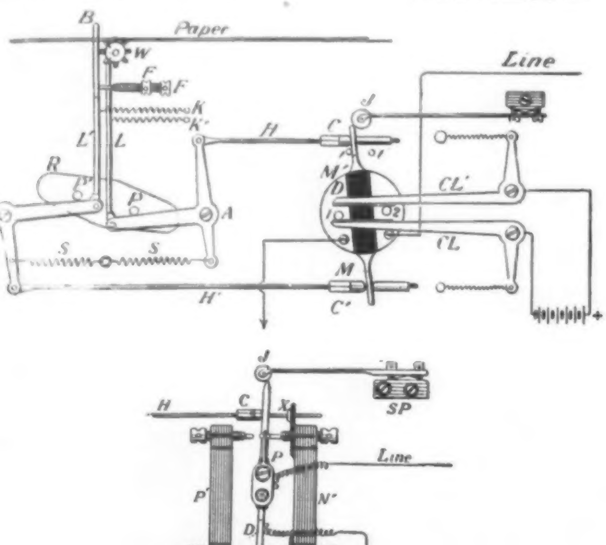


FIG. 1.—DIAGRAM OF THE WHEATSTONE TRANSMITTER.

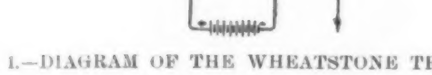


FIG. 2.

FIG. 5.

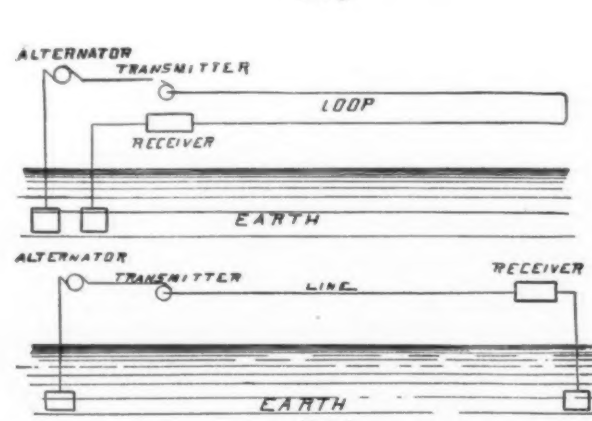


FIG. 6.

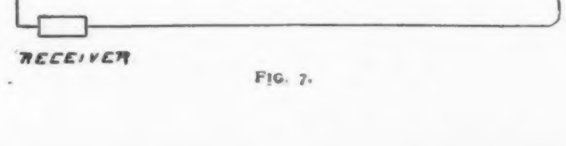


FIG. 7.

room in the General Post Office, London, which is conveniently wired for such tests, so that the terminals of any line can be connected to the room from the switchboards in the operating rooms above. The details of the experimental transmitter used were practically the same as those employed in the original experiments and described in the first paper to which reference is made. This part of the apparatus, however, was constructed specially for these experiments by Elliott Brothers, of London. The messages were prepared by fastening strips of paper upon the metal surface of a large wheel geared directly to the shaft of the alternator, as before described.

As it was desired to make tests over a considerable range of frequencies, the adaptability of the small Pupin alternator used in the first experiments justified cabling for this particular machine, which was loaned a second time for these trials. The alternator was driven by a one horse power Lundell motor from 100-volt constant potential mains, which were wired for the purpose from the dynamos used for lighting the building, and a storage battery was available for the excitation of the rotating field of the generator. Since the generator is in fact four alternators of 18, 22, 26 and 30 poles respectively, and the motor could be run regularly at very slow speeds as well as high, this combination with a field excitation, which could be varied at will, permitted a wide range of frequencies at any desired voltage. Transformers were used when desired. For the most rapid speeds the chemical receiver, using the same formula of Delany and operated in the simple manner described in the first paper, was employed with the synchronograph. The paper was prepared and used in the form of sheets instead of tape.

The preparations for the first trials over actual lines, which were made on Sunday, August 8, 1897, included a series of observations to determine the variations of a voltmeter of the magnetic type, with changes of frequency. For this purpose the Kelvin multicellular electrostatic voltmeter of the General Post Office was used for comparison, and observations taken over a range of frequencies from 200 to 610, and curves plotted by which any given reading of the instrument could be read as true volts. The unreliability of instruments of this magnetic type, when used for frequencies outside of that for which they are designed, is well known, and for a frequency of 610 the readings were but 73 per cent. of those of the electrostatic instrument, while for a frequency of 325 this was increased to 94 per cent., the readings coinciding at a frequency below the latter.

Since the curves plotted from the observations with the electrostatic instrument proved to be straight lines passing through the origin, showing that the voltages are proportional to the speeds with constant excitation, the readings of the electrostatic instrument were probably correct.

SUNDAY, AUGUST 8, 1897.

The location of each of the four lines is shown in the accompanying map, Fig. 4. The first line was from London via Leeds to Newcastle-on-Tyne, and return to London via York. The data are given in the following table:

Section		Mileage		R	K		Total K	K R
From	To	Open	Covered	B A Units	Open	Covered		
London	Leeds	202·80	1·83	550	3·04	·76	3·80	2090
Leeds	London via Newcastle-on-Tyne	356·14	36·08	3770	5·34	0·73	15·07	56824
		558·94	37·91	4320	8·38	10·49	18·87	81518

From London to Leeds, copper wire, 400 pounds per mile; diameter, 0·158 inch; resistance, R = 2·225 ohms per mile.

From Leeds to London, copper wire, 200 pounds per mile; diameter, 0·112 inch; R = 4·45 ohms per mile; except 82¾ miles of iron wire, 400 pounds per mile, diameter, 0·171 inch; R = 14 ohms per mile.

K for copper wire 200 pounds per mile = 0·0150 microfarad per mile.

K for copper wire 400 pounds per mile = 0·0156 microfarad per mile.

[NOTE.—The capacities given are for a line with earth connection at both ends, and when this is not the case, the circuit being a simple metallic loop, it is considerably reduced in value. When the loop is of the kind described, having the going and returning conductors separated by several miles instead of being upon the same poles, it is seen that the total distributed capacity of the loop is approximately a quarter of its value when the earth connection is used. Let the point, A, Fig. 5, represent the cross section of the direct conductor, and B that of the return, the distance between A and B being large as compared with their distance from the earth. When the line is earth-connected as represented by either diagram in Fig. 6, the capacity is taken from the conductor to earth all the distance around the loop; for one plate of the condenser is the whole conductor, and the other plate the earth. Let the capacity per mile when earth is used be denoted by k, and the length of the whole loop in miles by m. Then, if the total capacity is K, we have

$$K = km \text{ when earth-connected.}$$

If no connection is made to the earth, and the circuits are as represented in Fig. 7, then the capacity of the system is taken from one conductor to the other instead of to earth. Hence one plate of the condenser is the outgoing conductor, A, and the other plate the return conductor, B. The capacity from A to B when separated several miles is different from that when they are on the same poles near together. The earth is a neutral conductor comparatively near to each conductor, A and B, and has upon it equal charges of the opposite polarity, one kind being under conductor, A, and the opposite kind under B, each being equal to the charges upon the wires, A and B. The capacity of the condenser from A to B is therefore equal to the capacity of two condensers in series having a capacity of k per mile. The equivalent capacity K' of condensers in series is

$$K' = \frac{1}{\Sigma \frac{1}{k}}$$

In this case the condensers in series are but two in number and of equal capacity k per mile, hence

$$k' = \frac{1}{2} k$$

The length of one plate of the condenser is only equal

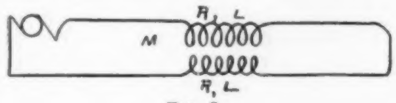


FIG. 8.

to the return conductor, so that the whole capacity of the loop when not earth-connected is

$$K' = \frac{k}{2} \times \frac{m}{2} = \frac{1}{4} K$$

or one-quarter of the capacity when earth-connected.

Although the capacity of the system is the same in the two diagrams of Fig. 6, the earth intervenes between transmitter and receiver in one instance, while it does not in the other, and there is theoretically a difference between the wave propagation in the two cases, the velocity in the earth, however, being approximately the velocity of light. The difference is so slight that it has no appreciable effect in practice. This question has been settled by years of experience with the Wheatstone system, since it is known that the speed of operation is practically the same whether the instruments be side by side or separated by the whole length of the line, provided the capacity times the resistance is the same in the two cases.

The value of KR in the line to Newcastle-on-Tyne when not earth-connected was, therefore, 20,380 instead of 81,518, and the one loop was employed as two distinct lines. When earth is used, it is approximately equivalent to a line using earth return equal in length to the entire loop, and when not earth-connected it is equivalent to an actual line using earth return of half the length of the loop.]

With no earth, messages were received with ease at a frequency of 652 or 1,304 alternations per second. This frequency was limited by the fact that the greatest number of poles to the generator was 30 and the number of revolutions to produce this frequency was 2,608,

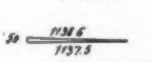


FIG. 9.

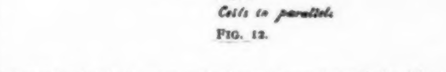


FIG. 10.

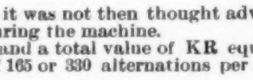


FIG. 11

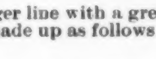


FIG. 12.

beyond which it was not then thought advisable to go for fear of injuring the machine.

With earth and a total value of KR equal to 81,518, a frequency of 165 or 330 alternations per second was reached.

To obtain a longer line with a greater value of KR, a second loop was made up as follows:

Section		Mileage		R	K		K	K R
From	To	Open	Covered	B A Units	Open	Covered		
London	Glasgow	402·72	5·74	1075	6·04	2·36	8·40	9030
Glasgow	London via Edinburgh	417·84	38·30	4185	6·84	9·52	15·76	65950
		820·56	44·04	5260	12·88	11·88	24·16	127082

Route.—London via Leeds to Glasgow, and return via Edinburgh, Newcastle-on-Tyne, and York to London.

London to Glasgow, 400 pounds per mile, copper wire. d = 0·158 inch. R = 2·225 ohms per mile.

Glasgow to London, 86 miles of copper wire, 100 pounds per mile, d = 0·079; R = 8·90 ohms per mile; 47 miles of iron wire, 450 pounds per mile; d = 0·181; R = 12·0 ohms per mile.

As before through this line without earth, KR being 31,771, a current was sent having a frequency as high as safety to the alternator permitted, viz., 652 complete waves per second, and no limit of speed due to the line was reached, the messages being received with perfect clearness. With earth and KR = 127,082, no records were received at all on this date on account of not having at hand a suitable transformer to produce high enough potential at the slow speed of the alternator necessary. Before the next trials were made a suitable transformer was available to deal with a value of KR much larger than the above.

To test the fact that the messages were actually passing through Glasgow, and that the records were not being caused by leakage currents across the line at some point, an experiment was made of breaking the circuit by the operator at Glasgow at a certain time and restoring it again five minutes later. Before and after the line was so broken the messages were transmitted readily, while during the time it was broken not the slightest record could be obtained.

An instructive experiment, illustrating forcibly the influence of increase of distributed capacity upon aerial wires, was that of suddenly plugging in and out the earth connection, thereby practically changing the length of the line two-fold, when at the instant the earth was connected the motor would slow down and labor under the increased load.

THE SYNCHRONOGRAPH AND WHEATSTONE RECEIVER.

On Thursday, August 12th, it was decided to try the synchronograph with the Wheatstone receiver, which was at hand in the same room. This was done, and without any alteration of the receiver whatever it responded readily to each wave of current from the alternator. Messages were then correctly transmitted and received. This was done by two different methods. First, the messages were interpreted by the portions of current omitted, as described in the former paper, the omission of a single mark denoting a dot and two marks a dash, the marks themselves meaning spaces. Second, the presence of the marks was used for dots and dashes, and one mark denoted a dot, while two or three consecutive marks denoted a dash. The marks are all regularly spaced, and the eye experiences no difficulty in reading the dash, even though it is made up of two or three separate consecutive marks instead of a single long mark, since the length of the dash is of more moment than the continuity of the mark.

These preliminary tests developed the fact that messages could be received by the Wheatstone receiver in the laboratory faster with the synchronograph than with the regular Wheatstone transmitter. When this discovery was made, the engineer-in-chief desired to make a more extensive series of experiments and try the synchronograph with the Wheatstone receiver over actual lines having a value of K R sufficient to reduce the speeds. As the Wheatstone receiver was to be used with the alternating current, the first thing wanted was a knowledge of its constants. The inductance of the instrument measured by the impedance method was found to be 0·875 henry for a single coil and 3·46 henrys for the coils in series. When the coils were connected so as to give opposing magnetic effects the measurements gave an inductance of 0·187 henry. The two coils of the receiver are wound together, the two wires being wound as one upon the spools in such close proximity that the mutual induction between the coils is at its maximum, and is nearly equal to the inductance of each coil. In such a case the inductance of the two coils in series should equal four times that of a single coil if there were no magnetic leakage, and when connected in opposition the inductance would vanish. This agrees approximately with the measurements when allowance is made for small magnetic leakage.

The circuit is represented in Fig. 8, where the two coils of the receiver are represented in series and also in mutual relation.

When the receiver coils are connected in parallel, the inductance is practically the same as that of a single coil, since the two coils are like a single one having larger wire, the number of turns being identical.

Figs. 9, 10, 11 and 12 illustrate the relations between the impedances, resistances and reactances of the Wheatstone receiver coils when connected in different ways. Fig. 9 is for a single coil alone, Fig. 10 the two connected in series to assist, Fig. 11 in series to oppose, and Fig. 12 in parallel, each being drawn for a frequency making $\omega = 1,300$.

An inspection of the diagrams shows that in every case, except where the coils are in series to oppose, which would never be practicable because there is then no magnetization developed, the reactance is many times larger than the resistance of the coil. In the cases when they are in series or in parallel it is 22·75 times as much, and for the single coil 11·375.

When the receiver is used with reversing currents, such as are employed in the Wheatstone system, or with alternating currents, the impedance is the important element, and the value of the resistance makes very little difference, provided it bears so small a ratio to the impedance. If the coils of the Wheatstone receiver are increased to 400 ohms, for instance, instead of being 200 ohms as at present, the impedance would only be increased about 13 ohms or 3½ tenths of one per cent.

It is found in practice, as above mentioned, that better results are obtained by the use of condensers, as indicated in Fig. 3. Instead of shunting the condenser directly around the receiver, however, a large resistance is first inserted in series between the receiver and the line and then the condenser shunted around this resistance. This inserted resistance is often larger than the impedance of the receiver. The reason for this particular arrangement of circuits seems to be that the waves have different lengths and the square topped wave of electromotive force is used.

When the synchronograph was used with the Wheatstone receiver, this resistance with its shunted condenser was removed from the line and the condenser shunted directly around the receiver, as seen in Fig. 13.

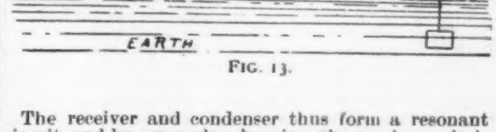


FIG. 13.

The receiver and condenser thus form a resonant circuit, and by properly choosing the condenser it is possible to increase the receiver current materially, making it larger than the line current. This is the benefit of using a condenser, but the capacity for the best effect should vary with the frequency of alternation. By knowing the inductance of the receiver and

the frequency, the condenser capacity can be calculated by the formula

$$C = \frac{1}{L\omega^2}$$

where C denotes the capacity of the condenser, L the inductance of the receiver, and ω is 2π times the frequency. The value of the capacity for any frequency is not very critical, that is, a condenser will improve the working for a considerable range of speed.

At present the speed of operation of the separate Wheatstone transmitters is under the control of the operator, and is independent for each instrument. In London the speed of operation of each operator is noted daily, and if found to be below a certain required limit an explanation is required from the operator. With the use of the synchronograph it is practicable to operate a number of transmitters from the shaft of one alternator, and it may be so arranged that the speeds are fixed beyond the control of the operator.

THE SPEEDS OBTAINED BY THE WHEATSTONE SYSTEM.

The present perfection of the Wheatstone system is much superior to that obtained with the original instruments. This improvement is due to Mr. Preece, who has gradually increased the speed from one or two hundred to six hundred words per minute. The Wheatstone system has been in commercial operation for so long a period that the speed expected on any given line is accurately known, and may be represented closely by an equation of the form

$$K\,R\,W = \text{a constant},$$

where K denotes the total distributed capacity of the line, R the total resistance, and W the number of words per minute. This constant depends upon the kind of line used, and differs for iron and copper wire and for cables. The values of the constants determined by a series of experiments extending over a long period are

10×10^6 for aerial line of iron wire.
12×10^6 for aerial line of copper wire.
15×10^6 for submarine cable with condenser at one end.
18×10^6 for submarine cable with condensers at both ends.

These equations are exhibited in graphical form in Fig. 14, where the values of KR are abscissæ and W ordinates. With these variables the curves become equilateral hyperbolas, having the axes as asymptotes. There is one curve given for each of the four constants above representing different kinds of lines. It is to be noted that all the curves terminate at the limit of 600 words per minute, as this is found to be very near to the mechanical limit of operation of the receiver due to the inertia of the moving parts, the spattering of ink or other causes.

A copper aerial line having KR equal to about 30,000 will reduce the Wheatstone speed to about 400 words a minute; and when a line exceeds this it is customary to insert an automatic repeater, by which the speed is maintained over longer distances. Speeds of 400 words a minute are regularly maintained in England in commercial working, while the limit of the commercial working in the United States is considerably lower, about 200 words per minute.

A fifth curve is added in Fig. 14 to represent the speeds obtained with the Wheatstone receiver when operated by the synchronograph. The ordinates of this curve are about three times those of the corresponding ones for copper air line for all values of KR.

A curve for the synchronograph and chemical receiver might be given which would lie above any curve shown because of the shorter code permissible with this receiver. There would then be no limit at 600 words due to the mechanical construction, so that the curve would extend up into thousands of words per minute. The curve is not shown, because the experiments have not yet established the law of speeds for this combination of instruments.

(To be continued.)

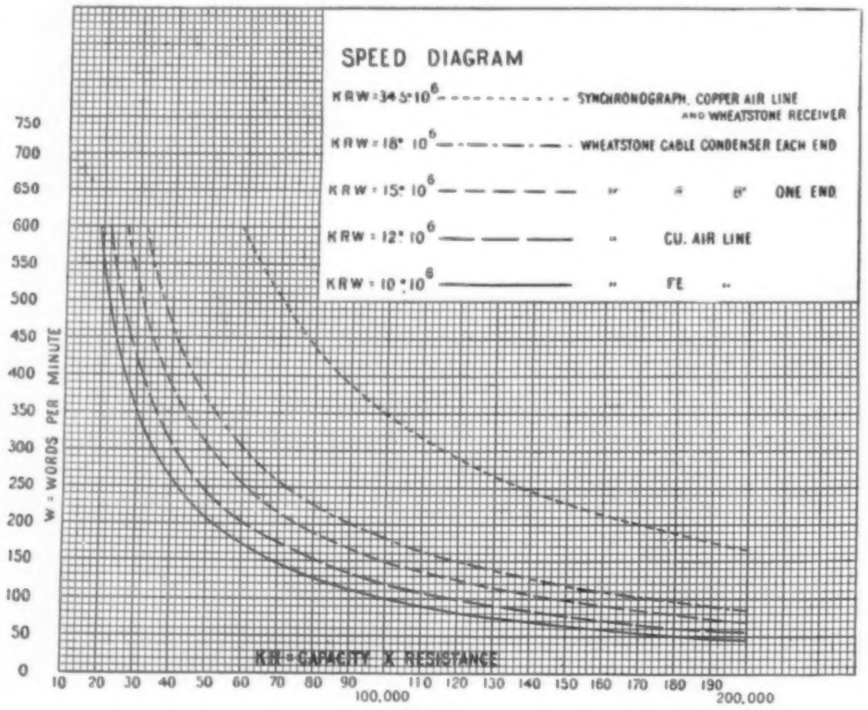


Fig. 14.

THE ROLE OF COSMIC ETHER AND SOLAR HEAT IN THE DISINTEGRATION AND FORMATION OF MATTER.

NEW WORKING HYPOTHESIS.

By Charles E. de M. Sajous, M.D., Philadelphia, Pa.*

Some twenty years ago, Prof. Maxwell, as the interpreter of advanced thought, expressed the view that all the physical manifestations, gravitation, cohesion, capillarity, elasticity, chemical affinity, heat, light, electricity, including magnetism, and even vital force, required the existence of a medium such as that defined by Plato, "a substance purer than air, which, being diffused throughout space, cannot be weighed," or as imagined by Newton, "a most subtile spirit which pervades and lies hid in all gross bodies." Maxwell's view has but grown apace with time, and so important a factor in physical science has this agent become that Dolbear, in a work† in which the role of ether as the fundamental principle of all that our senses perceive is graphically described, writes: "Now, it is either that theory or nothing. There is no other one that has any degree of probability at all." Lord Kelvin emphasized our right to accept ether as the basis of synthetic conjecture when he said in his lectures on Molecular Dynamics at Johns Hopkins University, "Instead of beginning by saying that we know nothing about the ether, I say that we know more about it than we do about air or water, glass or iron. It is far simpler; there is far less to know. Its natural history is far simpler than that of any other body."

Ether is assuming no less an important role as the primary element of matter, and it may be affirmed that the doctrine of Epicurus, transmitted to posterity by the writings of Lucretius, is fast being relegated to the rank of a negative hypothetical system. His small, hard, lifeless atoms accounted for the permanence of bodies, but they utterly failed when that marvelous product of modern times, the spectroscope, revealed molecular vibration. We are returning to the broader conception of Thales, who imagined the substance of which the world is constituted as essentially one capable of assuming shapes and functions as diverse as the resulting phenomena are numerous. Indeed, the day is probably near when scientific research will confirm the loftier doctrines of Heraclites, who saw through the light of his genius that matter was in reality the active manifestations of a primary element endowed with vibratile energy, a living, animated, divine entity.

While the existence of a primordial homogeneous substance is rapidly affirming itself, the part played by it in the organization of what might be termed the "chemical atom," the ultimate particle of matter as matter presents itself to our senses, is still unknown. "The formation of the molecule," writes Maxwell, "is an event not belonging to that order of nature under which we live. It is an operation of a kind which is not, so far as we are aware, going on on earth or in the sun or the stars, either now or since these bodies began to be formed. It must be referred to the epoch, not of the formation of the earth or of the solar system, but of the establishment of the existing order of Nature, and till not only these worlds and systems, but the very order of Nature itself is dissolved, we have no reason to expect the occurrence of any operation of a similar kind." The results of experimental investigation have apparently sanctioned this view; the futile efforts of the chemist to disintegrate the body that is now considered as the ultimate indivisible particle of matter have added potent evidence in favor of the generally accepted axiom that, although an ethereal principle may form the texture of matter as our senses recognize it, there is nevertheless a barrier that none can trespass, a transition stage between ether and its active manifestation which it is not within human power to define.

Must we consider this verdict, based upon the evidence of but one branch of physical science, as final? Might a broader view of the question not elucidate fundamental features that would serve to transform what is now the property of science into a coherent system, showing a positive and logical sequence of the various phenomena known? It has seemed to me that a comparative study of these phenomena might furnish evidence pointing at least to a new line of thought that would eventually lead through the barrier now blocking the way. This paper is a record of the conclusions reached—a series of deductions based upon generally accepted scientific data. Indeed, if they are based on good ground, they tend to show that the formation of the molecule is an operation going on in space—on the sun, in the stars—now and ever since these bodies began their career, and that the molecule need not be referred back to the establishment of the existing order of Nature. Ether again appears as the fundamental principle of all that is physical and vital, all that serves the Creator's purpose in the development of another principle, far beyond ether and all its attributes—man's spiritual soul.

To argumentatively sustain the view that space is filled with a medium which transmits to us the light of the sun is unnecessary in these enlightened days. The postulate that motion cannot take place unless there is something to move is the ruling factor of all modern teaching. Mr. Cornu,* the distinguished president of the Astronomical Society of France, as conservative in his expressions on scientific subjects as his knowledge is profound, recently wrote: "Newton gave precision to the idea, vague before him, that force could not be transmitted without the intervention of a medium. Physicists and geometers have extended its application to many phenomena, electricity, magnetism, elasticity, etc., and have reached deductions that experience has generally verified in a most satisfactory manner. . . . One is forced to the conclusion that space is filled with an elastic substance. . . ." Ether, hypothetical as gravitation is hypothetical, has, like it, demonstrated its existence by the imposing array of its active manifestations. Without its presence in space, all the labors of the last century would be reduced to naught.

The ether, according to Lord Kelvin, is practically a homogeneous solid differing from water, glass and metal in being very much more finely grained in its structure. Although possessed of rigidity, it is absolutely elastic, and thus allows celestial bodies, such as planets, to pass through it without offering computable resistance. The bulb of an ordinary incandescent electric lamp is filled with ether which has replaced the air withdrawn; that it is transparent (in the sense usually accorded this word) is demonstrated by the manner in which the light emitted by the carbon filament is radiated on all sides.

The structure of units entering into the formation of ether has been studied mathematically by Helmholtz and Sir William Thomson (Lord Kelvin). The vortex ring, to which allusion will again be made, has firmly implanted itself as one of the pillars of modern science. Nearly a quarter of a century ago Maxwell wrote concerning it: "The vortex ring of Helmholtz, imagined as the true form of atom by Thomson, satisfies more of the conditions than any hitherto imagined. . . . But the greatest recommendation of this theory from a philosophical point of view is that its success in explaining phenomena does not depend on the ingenuity with which its contrivers 'save appearances' by introducing first one hypothetical force and then another. When the vortex atom is once set in motion, all its properties are absolutely fixed and determined by laws of motion of the primitive fluid which are fully expressed in the fundamental equations. The disciple of Lucretius may cut and carve his solid atoms in the hope of getting them to combine into worlds; the followers of Boscovitch may imagine new laws of force to meet the requirements of each new phenomenon, but he who dares to plant his feet in the path opened by Helmholtz and Thomson has no such resources."

Time has but sanctioned Maxwell's estimate. Diminutive beyond conception, millions of vortex rings enter into the formation of a single atom of matter, while their innate attribute, vibration, is constantly manifesting itself in modes, rhythms and degrees of intensity as varied as the multitude of manifestations of energy is great.

To more clearly define the hypothetical deductions forming the basis of this paper, it was deemed best to subdivide the general subject into a series of propositions and to append to each of these what sustaining evidence the various branches of physical science may have afforded.

DISINTEGRATION OF MATTER.

First Proposition.—The temperature of space being approximately that considered in laboratories as the probable point of molecular disintegration, absolute zero, the ether of space is endowed with disintegrating properties.

A feature relating to the ether of space that has received but little attention is its temperature. Text books on astronomy rarely allude to it, and the investigations published must have been few, judging from the paucity of references found in literature. That usually given, however, is 270° Centigrade below zero; and a recent study of the subject by Mr. Guillaume, of Paris,† showed that it could be approximately considered as being 267·4° below zero Centigrade. Seemingly of minor importance, this fact assumes suggestive value when the teachings of chemistry and physics show that an almost identical temperature, 273° below zero Centigrade, represents what in laboratories is termed "absolute zero," a condition of matter wherein chemical action is thought to become impossible, where, in other words, matter becomes dissociated.

As is well known, the elastic force of a permanent gas is increased by an elevation of temperature. "If a gas is placed in a closed inflexible vessel and heated," says Tyndall, "this increase of temperature is found to follow a definite course, or increment of elastic force due to the augmented energy of the gaseous molecules. Reckoning from 0° Centigrade upward, we find that every degree added to the temperature produces an

* Member of the Astronomical Society of France. The bulk of this article was prepared from a paper written for the Astronomical Society of France, and submitted for criticism to Mr. Guillaume, referee of the said society, whose many valuable hints are hereby gratefully acknowledged by the author. The original paper having been accepted, it will appear in the Bulletin de la Société Astronomique in due time.

† Matter, Ether and Motion, 1894.

* Revue Scientifique, February, 1896, pp. 133 and 136.

† Revue Scientifique, March, 1897.

increase of elastic force equal to $\frac{1}{273}$ of that which the gas possesses at 0°, and hence that by adding 273° we double that elastic force. Now, supposing the same law to hold good when we reckon from 0° downward—that every degree of temperature withdrawn from the gas, we diminish its elastic force, or the motion which produces it, by $\frac{1}{273}$ of what it possesses at 0°, it is manifest that, at a temperature of 273° Centigrade below 0°, we shall cease to have any elastic force whatever. The motion to which elastic force is due must here vanish, and we reach what is called the absolute zero of temperature."*

This proportionate decrease of elasticity being a fixed fact, Clément and Desormes† inferred that, at 273° below zero Centigrade, gases would cease to exist as gases. The labors of Raoul Pictet have confirmed this view, and it has received the sanction of Maxwell.

Organized matter seems to lose its ability to undergo chemical reaction, a condition in which, according to Dolbear, "there is not only no selective action, but no cohesion among atoms." . . . "All molecules would fall to pieces," he states; "that is, to atoms—quite dissociated."‡

This is further sustained by the testimony of Lothar Mayer: § "At the lowest temperature to which we can attain, the majority of chemical reactions studied under these conditions have been found to cease, or to proceed very slowly, so that it would appear that at absolute zero, −273° Centigrade—a temperature much below the lowest yet attained—chemical action would cease altogether from the absence of any form of heat motion whatsoever. Without heat there would be no exertion of the so-called chemical affinity." In other words, the staff sustaining the entire system as organized matter would disappear, and any substance taking part in its formation would reassume its original state.

An important feature in the case, however, is the fact that absolute zero has never yet been attained artificially, although it has been approached; hence, the total absence of heat which it represents may not result in a mere dissociation of matter into molecules or even atoms, but in complete disintegration into the true primary element of matter, ether.

Second Proposition.—Were absolute zero attained in our laboratories, the total absence of heat would cause matter to become dissociated into its primary element, ether.

Dolbear expresses the prevailing conviction of scientists when he writes that "all chemical phenomena are truly physical and referable to fundamental physical laws, and are fully explained when these mechanical conditions are pointed out." Berthelot's law, in virtue of which "the heat given out or absorbed in a given reaction measures the sum of the physical and chemical work accomplished in that reaction," affords a foundation which cannot be controverted. We have seen the influence exerted by a low temperature as shown by the labors of Clément and Desormes, Raoul Pictet, Lothar Mayer, Tyndall, etc. The influence of high temperature, on the contrary, is best shown by the spectroscope, which has indirectly demonstrated that the temperature of a body "varies proportionately as the square of its amplitude of molecular vibration." The ether units of Helmholtz and of Thomson, the vortex rings, closely packed, vibrate with increasing energy and greater free path in proportion as the temperature is raised. Hence heat is the dominant factor of kinetic energy. As the temperature is lowered the oscillations of the ether units are correspondingly reduced and there comes a time when, all heat ceasing, vibration—shown by the spectroscope to represent the active manifestation of atomic life—also ceases and the atom itself must succumb.

Further evidence may be obtained from the teachings of physics. It is generally accepted that free ether does not penetrate the individual atom and that it only fills the inter-atomic spaces. Once formed, atoms are held in their acquired shape by the vibrations of the surrounding ether. The law of the independence of the effects of force, applied in this connection, demonstrates that atoms are submitted to constant shocks from the surrounding ether units as long as the vibrations of the latter are sustained by heat. It naturally follows, therefore, that when the temperature is reduced to a point at which all heat is absent (absolute zero) the vibrations of the ether surrounding the atom cease, the force holding the ether units disappears, and the atom—until now held together by the repeated shocks received—becomes dissociated. We are thus brought back to the observations of physicists and chemists regarding the disintegrating influence of absolute zero, and to the hypothetical view formulated in the Second Proposition, that it is the atom, and not alone the molecule, that becomes dissociated.

A normal deduction which the foregoing remarks warrant is that space, owing to its proximity to absolute zero, must not only be the great depository of ether in its homogeneous state—capable of transmitting but not of absorbing radiant energy—but it must also be endowed with disintegrating properties. Indeed, it seems impossible, apart from all conjecture, that bodies unprotected by an atmosphere such as that intervening between our earth and the ethereal expanse should be able to resist the dissociating influence of so low a temperature as that of space, in view of what chemistry and physics have taught us on the subject. The following proposition may, therefore, almost be said to be beyond theoretical grounds:

Third Proposition.—The ether of space not only serves to transmit radiant energy, but it also acts, in virtue of its low temperature (or absence of temperature), as the disintegrator of bodies that are no longer serving a useful purpose in Nature.

The interstellar expanse is known to contain innumerable amorphous masses of undetermined origin. Is it reasonable to suppose that these bodies are perpetually accumulating in space and that Nature has provided no means for their gradual destruction? This subject will be considered farther on.

* Heat as a Mode of Motion, p. 72.

† Silliman, Principles of Physics, p. 456.

‡ Dolbear, Matter, Ether and Motion, p. 242.

§ Modern Theories of Chemistry, pp. 211; quoted by Dolbear, loc. cit., p. 339.

THE FORMATION OF MATTER.

It is reasonable to surmise that if the critical point of disintegration is represented by a condition wherein heat may be said to no longer exist, the critical point necessary for the formation of matter must at least be represented by an extremely high temperature.

The protective provisions of Nature, evidence of which we meet on all sides, could not be fulfilled were the transformation limits of such momentous functions as the creation and dissociation of matter not widely separated. Were moderately high or low temperatures capable of creating or dissociating matter, it becomes apparent that general chaos would soon ensue, through promiscuous elaboration and disintegration of matter.

That matter can be created under the influence of intense cold is an assumption that the condensation of gases and liquids might suggest; but, as we have seen, chemism becomes less active as low temperatures are attained, and it ceases or proceeds very slowly when absolute zero is approached. Hence cold can only be considered as a destructive factor. Heat would appear in the same light were ether considered as a gas, since heat but causes further separation of the molecules, the dissociation thus produced increasing in a fixed proportion as the temperature is raised. But it is perhaps needless to state, in the light of present knowledge, that ether is not an aggregation of molecules and therefore that it is not a gas! Ether, by reason of the tenuity of its units, may be considered as a homogeneous mass; so close are the vortex rings to one another that any oscillation in any part of the mass causes a correspondingly active motion in the surrounding units. Whatever be its vibratory amplitude, ether does not tend to become dissociated; whereas organized systems such as molecules always tend to fly apart under the influence of heat. "We cannot suppose the constitution o[illegible]ether to be like that of a gas in which the molecul[illegible] always in a state of irregular agitation," writes Ma[illegible]well,* "for in such a medium a transverse undulation is reduced to less than $\frac{1}{100}$ of its amplitude in a single wave length."

That a very high temperature is alone capable of so influencing the ether as to cause it to assume the condition we recognize as matter is also sustained by the known properties of vortex rings, and it is probable that if the creation of matter has never been realized in laboratories, it is because homogeneous ether has never been submitted to the influence of a sufficiently high temperature.

Fourth Proposition.—When through the agency of a high temperature a sufficiently high vibratory amplitude is reached, the ether units are capable of adhering to one another in fixed proportions and of forming elementary bodies, atoms, to which they transfer their vibratory energy.

We have already seen that, in virtue of Berthelot's law, "the heat given out or absorbed in a given reaction measures the sum of the physical and chemical work accomplished in that reaction." Again, we know that the temperature of a body varies proportionately as the square of its amplitude of molecular vibration. When vortex rings are submitted to the influence of heat, the amplitude of their vibrations is likewise proportional to that heat, but a sufficiently high temperature in their case brings other factors into play which form the prelude to the formation of matter.

Besides the inherent property of vibrating, vortex rings are capable of infinite changes of form and may execute vibrations of different periods, as molecules are known to do. "They are," to use Maxwell's words, "qualitatively permanent as regards their degree of implication, whether in 'knottedness' or 'linkedness' with other vortex rings," while the law of equality between action and reaction of Newton, and the general principle that a reaction, when equal to action, involves the preservation of quantities of motion in shock. We thus have ample grounds to sustain the hypothesis that when a homogeneous ether is exposed to a sufficiently high temperature, the vortex rings, by reason of the amplitude of the vibrations induced and the vigor of the resulting impacts, finally adhere to one another, become linked and knotted in groups, differing in kind, perhaps, according to the temperature, and finally form the system we recognize as the atom. Endowed with all the vibrating properties of the vortex rings which have entered into its organization, it thus enters into active life with all the attributes which chemistry would demand. Created by heat, sustained by heat, it could but succumb to the disintegrating influence of the absence of heat—the absolute zero.

FORMATION OF MATTER IN SPACE.

The ether of space, by reason of its homogeneousness, its density and its temperature, would seem to present all the conditions of a perfect medium for the creation of matter in accordance with the hypothesis submitted herein. The presence of a seething mass, such as the sun, in the midst of the ether of the ethereal expanse, seems certainly to suggest the possibility of phenomena surpassing in importance those already recognized; and if an intense heat can create matter, our luminary should indeed be able to supply it. Analyzed, this idea seems to gain force at every step.

Fifth Proposition.—The sun being surrounded by ether, the heat developed is capable of transforming that substance into elements which are immediately deflagrated and returned to space as products of combustion by means of the protuberantial explosions.

Sir William Thomson,† by calculations based upon the mechanical equivalent of heat, supported the best theory advanced concerning the origin of solar heat—that of Helmholtz founded upon solar contraction. The theory that meteors contribute sufficient fuel to supply our luminary's tremendous heat, and other hypotheses so far devised, are usually considered as auxiliaries to that of Helmholtz. Many astronomers, however, even now consider the entire problem as unsolved. Young, for instance, holds that the subject is not yet understood; Flammarion believes that the prodigious radiation must be due to other causes, etc. Helmholtz's hypothesis appears as the true one for the maintenance of the heat of the nucleus, but the utilization of the surrounding ether by the sun seems alone capable of accounting for the thermic and explosive phenomena of the surface, while complying with desiderata that science has established as laws by observation elsewhere. "If the sun be a burning mass," writes Sir William Thomson, "it must be more analogous to burning gunpowder than to a fire burning in air." The theory submitted herein seems to be the only one capable of satisfying this requirement; the chemical reaction already outlined is an exothermic one—requiring an auxiliary agent, heat, to start it. It seems to perfectly explain the tremendous explosions constantly occurring on the sun's surface. Once such a process started, it is known to continue indefinitely as long as the supply of the primary agent lasts. The fact that the ether of space is inexhaustible need hardly be insisted upon. If the deductions submitted are correct, therefore, the heat of the nucleus would be due to contraction, in accordance with Helmholtz's hypothesis, that of the corona including the protuberantial explosions, to the transformation and immediate deflagration of the surrounding ether.

* Encyclo. Brit., vol. viii, p. 572.

† Popular Lectures and Addresses on Solar Heat.

Sixth Proposition.—Cosmic dust is mainly composed of products of combustion, projected into space by the explosions on the sun's surface, and forms the coma and tail of comets, and indirectly meteoric bodies.

The process described would involve the presence, at least in the vicinity of the sun, of an immense quantity of combustion products, obscuring to a degree our luminary's radiance. Flammarion but voiced the observations of astronomers in general when he wrote: "The neighborhood of the sun is far from devoid of matter; there is a perpetual illumination of cosmic dust which the radiance of solar light hides from our view." In speaking of zodiacal light, he alludes to "an immense cloud of corpuscles surrounding the sun and extending beyond our planet's orbit." How clearly the products of combustion resulting from the deflagration of ether explains the presence of these corpuscles, need hardly be insisted upon. Hansky,* in his report upon the eclipse of August 9, 1896, notes: "Photographs of the corona show protuberances surrounded by dark spaces which could be masses of cold hydrogen in the act of being dispersed. . . . The hypothesis that coronal matter is projected into space along with other elements constituting the sun is very probably correct." That the protuberantial explosions should be capable of projecting far and wide the products of combustion from the sun's surface is shown by the length of the prominences. In the clear air of Colorado during the eclipse of 1878, Prof. Young traced two of them five or six degrees—a distance of at least nine millions of miles from the sun.

The spectrum of comets shows bright bands so strikingly similar to those produced by carbon that these nomadic bodies are considered as consisting mainly of carbon. Newcomb† in this connection writes: "It may be that comets will hereafter be found to consist of some combination of solid and gaseous matter, the exact nature of which is not yet determined." Towne‡ states that the spectrum of the coma is produced by reflected solar light, "which indicates that comets are formed of solid particles floating in a gaseous atmosphere." Evidence sustaining the view that every part of the comet, except the nucleus, is formed mainly of particles of carbon—the solar products of combustion—appears on all sides.

The theory now generally accepted as to the composition of the tail, according to Prof. Young,§ is that it is "formed by matter expelled from the comet by some solar action." How so enormous a quantity of matter as that represented can be created without a corresponding decrease in the dimensions of the nucleus and coma is not explained, however. The presence in space of carbonaceous particles satisfies the needs of the hypothesis as regards the quantity of matter, while the continuous explosions on the sun's surface amply account for the repulsion, from the comet, of the matter forming its appendage, and truly ascribed by Prof. Young and other leading astronomers to solar action.

Might there be in the force so exerted, and in the presence in space of these products of combustion and other forms of cosmic dust, an explanation of the retardation in the periodic time of Encke's comet, which led to the hypothesis of Albers, that this body met with a resisting medium in space? Strongly supporting this view is the fact that of all comets known, Encke's moves in by far the smallest orbit. It is therefore exposed to the retarding influence of the resisting elements to a correspondingly greater degree, and yields to them, while all the other comets are in no way affected. If the area of resistance only reached as far as the earth's orbit, Encke's comet would feel its effects during one-fourth of its revolution. Faye's comet, whose motions were investigated by Möller to ascertain whether its period was also affected by a resisting medium, does not approach the sun nearer than Mars' orbit, and could not, therefore, be influenced—thus verifying Möller's results, but sustaining at the same time the conclusion of Albers.

The tail of comets, as is well known, appears quite suddenly. "The comet of 1843," wrote Tyndall, "shot out in a single day a tail which covered 100 degrees of the heavens. This enormous reach of cloudy matter is supposed to be generated in the head of the comet and driven backward by some mysterious force of repulsion exerted by the sun." In the light of the theory advanced, the problem seems to find a ready solution: A comet's nucleus, whether a nebula or composed of meteoric stones, is attracted by the sun from regions far beyond the limit of the cloud of cosmic dust. It is first perceived as a round ball devoid of appendage and travels at a fixed rate of speed. As soon as it strikes the area of cosmic dust—products of combustion in our case—it crowds this substance before it, forming the coma, which in turn gives off on each side of the path traversed what portion of the substance it cannot continue to hold before it, thus forming the tail. This would seem to explain a curious phase of the behavior of comets on their return, after sweeping round the sun—the fact that the tail, instead of following the head, precedes it. The sun, while still attract-

* Bulletin de la Société Astronomique de France, March, 1897.

† Popular Astronomy, p. 407, ed. 1889.

‡ Astronomie Pratique, p. 392, ed. 1890.

§ Universal Guide and Gazetteer, p. 27.

ing the head of the comet, though with less force than before, continues nevertheless to eject its products of combustion, and these, impelled by the continuous explosions on the solar surface, which travel at a much greater speed than the head, form the tail as before; but it is also directed as before—away from the sun. Under these circumstances, the tail should disappear very soon, and this is precisely what happens.

"The meteoroids of the nucleus when they approach the sun seem to be repulsed," writes Swift. "Why the sun should attract a comet at one time and repel it at another is a mystery. Still, this represents what we see." In the light of the views presented herein, it seems plain that the comet would find itself repelled when near the sun by the coronal explosions. Indeed, it seems evident that comets owe their continued existence as such to this repulsive action; without it the majority at least of those entering our system would fall into the sun.

Why do not all comets and planets have tails? As to tailless comets, it is probable that the structure of the nucleus is not such as to mechanically influence or illuminate a sufficient quantity of cosmic dust to produce a tail of sufficient density to make it visible. Spectroscopy has shown that the nucleus is self-luminous, but that the tail shines with reflected light. So dense a body as a planet presents none of the attributes of a nucleus and is not self-luminous. If, therefore, it does leave in its wake a stream of cosmic dust, which is probable, there can be no reflected light to illuminate it, and it cannot be discerned.

To account for the various shapes assumed by the tail is also necessary. The nature of the nucleus and its outline must doubtless affect the medium traversed in such a way as to give each body its own identity. A semilunar nucleus, with its convexity forward, such as that seen in Coggia's comet for instance, would impinge upon the surrounding cosmic dust and gases in a manner differing greatly from that to be expected from one presenting a narrow transverse diameter. The various appearances presented by Halley's comet in different parts of its orbit illustrate this fact.

It seems quite probable, judging from the evidence adduced, that the coronal explosions have for their main function that of projecting far and wide the products resulting from the combustion of ether. At first consisting of gases, the rejected substances are gradually cooled and condensed by the low temperature of space. When they reach regions, probably beyond our planet, where the critical point, absolute zero, is reached, the process of destruction begins, and soon the units of ether, united by the sun, are dissociated and returned to space, Nature suffering no waste.

The fact demonstrated by Newcomb that not less than 146 billions of shooting stars fall upon our planet yearly gives an idea of the quantity of the inorganic matter surrounding us. The concentration of the cosmic dust in the wake of comets should therefore be marked in proportion. M. Schiaparelli has noticed that meteoric showers coincide precisely with the orbit of comets. "Shooting stars, uranoliths, and aeroliths seem united by a common origin," writes M. Flammarion. The products of combustion rejected by our luminary supply the required original cause. The belief that meteoric bodies can thus be constituted, however, in no way affects the view that other amorphous masses, especially the larger ones, such as the asteroids, may originate otherwise, or be the vestiges of former planets. On the contrary, the presence of all these varied masses of detritus could but sustain the view that space is the great field where the organized matter is constantly being created, but where refuse matter is gradually being disintegrated.

Considering the subject as a whole, we now find ourselves sustaining a general universal law that science has amply confirmed. We know that all heavenly bodies, suns and planets, after their nebular period has passed, begin their career with a high temperature as the ruling factor, and that a planet such as our earth is gradually cooled down by the influence of the low temperature of space. This influence probably never ceases. Protected by its atmosphere, our terrestrial abode is serving out its period of usefulness, and what we see of Nature's marvelous resources represents an interval in the downward progress of the planetary thermometric scale. The time will finally come when all organic form will become inorganic amorphous matter. Chilled in death as we all are, our earth will gradually return to the great storehouse whence she originated, in accordance with general principles (perhaps those herein enunciated) which form but a step in the scale of a great general law, that of evolution.

Experiments recently conducted by Immendorf show that there is no better material for packing ice with in stores than peat. But all peats are by no means of equal value. The most suitable is the mossy peat, which, whether applied in firm sods or in the form of a litter, by far surpasses all its rivals. The more earthy matter a peat contains, the less suitable it is in the ice house. Great attention should further be paid to the peat being kept dry, and moisture should be removed before the material is brought into the ice house. Although, on the whole, a loose material is a poorer conductor of heat than the same substance in a compressed state, large interstices and anything like air passages should be avoided. For these reasons, a slight compression is advisable, and the joints of sods should be smeared with loose peat. Suitable turf keeps the ice in much better condition than straw or sawdust. In the Mittheilungen aus den Gebiete des Artillerie und Genie Wesens Major Petriss discusses other applications of peat.

A speed of 73 miles per hour is recorded for a locomotive on the Pittsburg, Cincinnati, Chicago & St. Louis Railway in a recent run with eight heavy cars between Columbus, Ohio, and Xenia, in the same State, a distance of 55 miles, which was covered in 47 minutes, says The American Engineer and Car Builder. The actual time of the run was 56 minutes, but this included three stops, one crossing slow-down and a delay of four minutes at London, making a total loss of nine minutes. The locomotive was built by the Schenectady Locomotive Works.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.